

USE OF VIRTUAL ENVIRONMENTS IN
INTERIOR DESIGN EDUCATION:
A CASE STUDY WITH VRML

A THESIS
SUBMITTED TO THE DEPARTMENT OF
INTERIOR ARCHITECTURE AND ENVIRONMENTAL DESIGN
AND THE INSTITUTE OF ECONOMICS AND SOCIAL SCIENCES
OF BILKENT UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF FINE ARTS

By
Ayşe Şagun
May, 1999

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AYSU SAGUN

May, 1999

Aysu Sagun

karafendakci@post.bilkent.edu.tr

NK

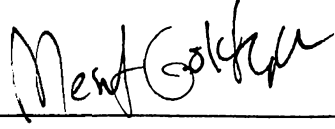
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I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Fine Arts.



Assist. Prof. Dr. Mesut Göktepe (Supervisor)

I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Fine Arts.



Dr. Burcu Şenyapılı (Supervisor)

I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Fine Arts.



Prof. Dr. Mustafa Pultar

Approved by the Institute of Fine Arts



Prof. Dr. Bülent Özgüç, Director of the Institute of Fine Arts

ABSTRACT

USE OF VIRTUAL ENVIRONMENTS IN INTERIOR DESIGN EDUCATION: A CASE STUDY WITH VRML

Aysu Sagun

M.F.A in Interior Architecture and Environmental Design

Supervisor: Assist. Prof. Dr. Mesut Göktepe

May, 1999

Communicating spatial thought and visual perception is not an easy process. However, introducing virtual worlds into communication and visual perception of complex concepts and information make the process easier. The observer using Virtual Reality (VR) applications navigates within an information environment that increases data awareness and understanding with the help of specific effects such as immersion, presence and interactivity (Dagit, 1993). These capabilities of Virtual Environments (VE) can easily be used for the design education, as well as the designer together with the clients uses them during the design phase. In this way, the students would have the flexibility in the education life since there will be no restriction and limitation in the time and place for following the lectures. Within this context, this thesis investigates the benefits of VE in interior design education using web-based communication. When preparing this application Virtual Reality Modelling Language (VRML) has been used as a tool which is a language for describing multi-participant interactive simulations, in other words, VE, networked through the Internet. In the study, the logic of how VRML works has been explained including various examples. The design process and navigation in VRML world is experienced. Additionally, virtual libraries for texture, material and furniture are prepared. The research has been concluded with the construction of a sample extension course design for the senior Interior Architecture course: Modular Interior Systems, using VRML.

Keywords: Web-based architectural education, Interior Design Education, Virtual Reality, Virtual Environment, Collaborative Design Environments, Virtual Reality Modelling Language

ÖZET

SANAL ORTAMLARIN İÇ MİMARLIK EĞİTİMİNDE KULLANIMI: VRML İLE BİR UYGULAMA

Aysu Sagun

İç Mimarlık ve Çevre Tasarımı Bölümü

Yüksek Lisans

Tez Yöneticisi: Y. Doç. Dr. Mesut Göktepe

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Mekansal düşünceyi ve görsel algılamayı anlatmak kolay değildir. Ancak, sanal ortamların karmaşık kavramların ve bilgilerin iletilmesinde ve görsel algılamada kullanılması bu işlemi kolaylaştırır, çünkü sanal gerçeklik sistemlerini kullanan gözlemci fiziksel ve psikolojik olarak sanal ortamda bulunma hissi ve etkileşim gibi özel efektler sayesinde, veri algılamasını arttıran bilgi ortamında gezinir. Sanal ortamların bu özellikleri, tasarımcının müşterisiyle olan ilişkilerinde kullanılabileceği gibi tasarım eğitiminde de kullanılabilir. Böylece, dersleri takip etmek için zaman ve yer kısıtlaması olmayacağından, öğrenciler eğitim hayatlarında bir serbestlik kazanırlar.

Bu bağlamda, bu tezde Web tabanlı iletişimi kullanarak sanal ortamların iç mimarlık eğitiminde kullanımı araştırılmıştır. Konuyla ilgili örnek bir uygulama hazırlanması amacıyla araç olarak internet üzerinden de kullanılabilen çok kullanıcı etkileşimli simülasyonları, diğer bir deyişle sanal ortamları, tanımlayan bir dil olan Sanal Gerçeklik Modelleme Dili (VRML) kullanılmıştır. VRML ortamında tasarım aşamaları ve gezinti denenmiştir. Ayrıca doku, malzeme, detay ve mobilya için sanal kütüphaneler hazırlanmıştır. Araştırma dördüncü sınıf iç mimarlık dersi olan “Modüler İç Mekan Sistemleri” dersi için hazırlanan örnek bir yardımcı ders tasarımı ile sonuçlandırılmıştır.

Anahtar Sözcükler: Web tabanlı mimari eğitim, İç mimarlık eğitimi, Sanal gerçeklik, Sanal ortamlar, Ortak tasarım ortamları, Virtual Reality Modelling Language

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With my deepest gratitude, I dedicate this study to my family.

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1 INTRODUCTION

1.1 GENERAL

This thesis investigates the use of Virtual Environments (VE) in interior design education with a case study involving the design of an extension for the senior course Modular Interior Systems in the Virtual Reality Modelling Language (VRML) environment. The benefits and capabilities of VE and Internet are also studied related to this concept.

Drawing, as an essential tool for the designer is a type of modelling that helps the expression and the presentation of the mental concepts of the designer (Donath and Regenbrecht, 1996). The tools that the designer uses for expressing these mental concepts are changing as the technology develops (Zobel, 1995). Computers, which were originally designed to be used as a mathematical tool, have also been integrated into design works with the recent developments in technology. They are not far from the designers any more, since they have started to be a vital element of the design environment. Today, computer systems accompany the function of the drawing boards and pencils. In addition to the pencil, paper, eraser, stencil and ruler, designers also use tools such as computer and peripherals like plotter and scanner. This alternation in equipment and platform is changing the means the designers think and work. However, in order to utilise the full power of this media, efficient use of

computer systems is necessary. Thus the computer aided design (CAD) education of the new generation designers becomes essential.

Unfortunately, there is a common idea of use of computers as a tool only for presentation and documentary purposes, which obstructs the efficient use of the capabilities of computers. However, currently, computers provide immersion, presence, interactivity, autonomy and collaboration with the development of the Virtual Reality (VR) systems (Bertol and Foell, 1996). These capabilities of VE can easily be used for the design education, as well as the designer, together with the clients can use them during the design phase. In this way, the time and place constraints are reduced for following the courses. Moreover, students would learn how to save their time and effort; minimise errors; take client's attention with presentations on computer, which would help them in their future professional life using the computers.

Furthermore, new information technologies change the way people work, supporting the request for easy accessibility to global information and collaboration. For instance, Internet and World Wide Web (WWW) enable geographically distributed people to interact and work together. Information can easily be available for students on the Internet. However there is still a lack of sophisticated tools to provide adequate and satisfactory teaching environments (Jasnoch et al., 1996), especially in design education. Nevertheless there is a great development in computer technology than it was predicted. When we look back, the computers were not seen as vital tools as it is seen today (Pinet, 1997). It is apparent that the situation will be similar for VE and Internet in the near future depending on the technological developments. Their importance and advantages are increasing day by day. The developments that will

take place in the future in computer graphics and navigation processes will attract more people to use VE on the Web. For instance, today the majority of Web users is computer professionals but there is an increase in non-professionals using the Internet as a result of the development in global information and technology of Internet and VE.

Tools are being developed to create more powerful and efficient systems for Internet. Global information exchange has become possible with the Hyper Text Mark-up Language (HTML) which is a language used for serving information with 2D images, textual data and sound using hyperlinks over the Internet. Furthermore, VRML has been developed as a result of the need for three-dimensional (3D) graphics representation and 3D animations on the Internet. VRML is capable of representing static and dynamic 3D multi-media objects on various systems together with hyperlinks addressing text, sound, movie or images. There are many available VRML browsers, authoring packages, editors and conversion programs for the creation and visualisation of VRML worlds. Using these tools, it is possible to build large dynamic 3D interactive worlds that are usable on a wide variety of computing platforms.

1.2 VIRTUAL ENVIRONMENTS VERSUS TRADITIONAL 3D COMPUTER GRAPHICS IN DESIGN EDUCATION

The term VR may seem to have contradiction since reality can not be defined as virtual. However this term is used for creating and expressing an imaginary world in which human can participate. Thomsen (1994) discusses the virtual reality systems

of suggesting visually, audibly and tangibly alternating solutions for the space designed including their development referring to the researches done in recent years. Using virtual reality systems for creating a virtual world is not a new concept. Studies about VR had started with the development of man-machine systems in 1960s (Morgan and Zampi, 1995). The Sketchpad system of Ivan Sutherland that involves using light pens on a computer screen in order to draw vector lines, can be excepted as the first attempt for creating Human-Computer Interaction (HCI) (Abowd et al., 1993). HCI is studied for determining how computer technology can be made more useable by people, because in order to make designs in computer technology, the needs, capabilities and limitations of human should be understood.

Initially, studies about simulations for pilot training supported the development of VR applications and in the 1970's head mounted displays began to be used instead of projection screens (Thomsen, 1994). Since human interaction with the outside world occurs through information being received and sent trackers, which are the sensors mounted on the human body, was developed, later on. In this system, the inputs of the human occurs through the senses such as vision, hearing and touching and outputs through the motor control of effectors such as finger, eye, limb, head and vocal systems (Abowd et al., 1993)., Research conducted about VR in different universities throughout the world can be seen in the Thompson' s directory of research projects (1993). Also research studies about virtual reality and virtual environments are explained including the future potential and the areas that need to be studied related to virtual reality, in the proceedings of IEEE1996 VRAIS Symposium (Kavanaugh, 1996).

The development of VR tools related to HCI also provided collaboration in the virtual world. The technology related with VR systems can be found, in detail in

Latham (1994). Binkley (1996) states that computers are neither a tool nor a media but managers of complexity in which we participate.

New computer technologies such as VR enable participation in VE on a wide range of applications such as entertainment, education, medicine, visualisation, pilot training, architecture and human factors (MacDonald and Vince, 1994). As Coyne (1994) stated, VR applications create a world that exists only on the computer with a technology that presents a sensory information and feedback in order to produce a convincing illusion for the user to experience artificial worlds.

The VE created with VR technology can simply be defined as multi-dimensional interactive computer generated environments that enable people to act in and upon a space in real time. They are immersive environments that engage the participants on an immersive level (Goslin, 1996). The more the feedback provided by the computer the more realistic the user perceives the artificial world. In addition to the advantage of immersion, VE provide the effects of collaboration, presence and interactivity effects that is the sense of being physically and psychologically involved in the simulated environment.

Using these properties of VE, as Bar-Zeev and Jacobson (1994) have stated, virtual environment systems have revolutionised the nature of learning. The idea of using VE in education becomes more and more popular with the increasing amount of information on the Web and people requesting for education.

The use of VE is quite a new idea in architectural design education. Architectural design is a complex process that requires the understanding of the space that is being designed. Since, architecture is a static entity, its dynamics come from the aspects of moving through the space (Emmett, 1992). The spatial information given in

architectural drawings allows the designer to understand the space they design and helps them to determine the next step for the development of the project. There are a wide variety of techniques in drawing, for describing these spatial informations. Plans, sections and elevations are the two dimensional abstractions that help the observer to build the model of the space in their mind. Perspective is another technique, a two dimensional image representing views in the third dimension. In addition to the plans, sections, elevations and perspective, there are also computer modelling and interactive computer generated environments, VE, that give one the experience of the designed building in the same way it would be if the building were actually constructed (Emmett, 1992). Since human beings are able to move around the space they live in freely, observers in a VE would understand the spatial information given in the architectural design because they are sensitive to motion features such as speed and display quality. In addition to traditional architectural drawings, it is possible to use to advantage the ability to move in the virtual world for architectural design education as well as the architectural design process.

Computers can be used for architectural design practice, which is possible in two ways: traditional computer graphics and VE. On the one hand, the traditional computer graphics allow the designer to build both 2D and 3D representations on the computer. However this process restricts the observer while viewing the images since the observer does not have a chance to move around or manipulate the design. In the animation process of traditional computer graphics applications, it is only possible to create moving objects or cameras to experience the space designed. On the other hand, it is possible to create dynamic architectural representations in VE. The human gets much more excited as a result of flexibility of control in terms of movement provided in VE. The observer can directly access and manipulate the data

in VE (Kurmman et al., 1995). It can be composed of buildings or other elements, which can be either static or dynamic to provide interaction. The interactive components can be moved, rotated or scaled. For instance, It is possible to create swinging doors in a virtual world. The main difference between animation and virtual systems comes from the possibility of control over the content in VE. The real-time response of the computer to the actions of the users distinguishes the VE from other 3D computer graphics applications and simulations. In this way, the user becomes both the creator and the perceiver.

The models that define the geometry of the elements in the virtual world can be generated using various CAD softwares such as AutoCAD or 3DStudioMAX and converted into virtual worlds later on. These models can be built from a set of solids as well as created from bounded polygonal shapes. The two approaches are equivalent for visualisation purposes. Although the use of polygon based models are more easily importable into VR applications, it is better to use constructive solid geometry for complex structures, if boolean operations such as intersection, subtraction or union will be used. Additionally, the use of large number of polygons in the virtual world can effect the real-time interactivity.

The most effective means of rendering the object is the texture mapping, in which it is possible to simulate materials such as wood, metal, glass and stone. Moreover, using background images, animated textures or objects can create different effects to enrich the VE. Lighting of a virtual environment should also be considered because the same geometry can be perceived different under different lighting conditions. Directional, spot or ambient lighting can be used at any location and in any orientation in a VE.

The links between the objects, the hierarchical organization of parts of the same object and their dynamic behaviour are other characteristics of a realistic simulation. In addition to the movement, physical phenomena such as gravity, friction or fluid dynamics can also be added to create more realistic artificial worlds (Ames et al., 1996).

All of these properties and motion provided in VE give a sense of masses scaled in the space. Immersion, presence, interactivity and freedom to act and explore within the environment can be applied to all the phases of architectural design process with the help of walk-through or fly-by methods. This provides flexibility in design process, for instance, for trial and error studies, to see the missing or failing parts of the current design (Emmett, 1992). In addition to the flexibility provided by VE, in order to use VE in architectural design education, the VE constructed should be applicable to all phases of the traditional design process and it should provide a collaborative design environment to offer a more profitable method of studying (Aktaş, 1997).

1.3 INTRODUCTION TO WWW, HTML AND VRML

World Wide Web (WWW) is the name of a group of world wide information resources connected over the worldwide network, Internet. The Internet is a collection of thousands of networks linked by a common set of technical protocols which make it possible for users of any one of the networks to communicate with or use the services located on any of the other networks. These protocols are referred to as Transmission Control Protocol/ Internet Protocol (TCP/IP). Since the Internet is

built on the collection of different networks all around the world that contain many different types of computers, it needs TCP/IP to ensure communication of different computers (Hahn and Stout, 1994). The information is carried by computer networks. Local Area Networks (LAN) and Wide Area Networks (WAN) are used for this purpose. In LANs, the computers are directly connected to each other. WANs are formed when LANs are connected to each other (Kennedy and Musciano, 1996).

Information sharing through networks can be implemented by two separate programs that run on two different computers. All of the Internet services use the relation between client that makes use of the resource and the server that provides a particular resource (Roberts, 1997).

Each separate computer providing Internet services is called host and each computer that is attached to Internet is called node within the Internet. Every computer connected to the Internet has its own unique address and people who use the Internet have their own addresses. Connection to the Internet can be effected through:

- Dial-up connections (Telephone connections): A modem is needed, which is a hardware device that converts the computer signals to telephone signals so that Internet can be used from a distant location (Hahn and Stout, 1994).
- Connecting a terminal over a network cable: It is possible to have an Internet host at a school, service provider or firm so that Internet can be used directly over the network connection.

Over the Internet, there is an enormous number of sources to guide and train students about the design process including information about the history of art and design, existing design examples and issues concerning other architects or designers. Thus,

in addition to the use of VE in architectural design education, WWW can be used as a tool for gathering information, examining existing samples and communicating with the other staff over the Internet to improve the quality of design education. Using one of these connections, the student can reach to the information sources from all around the world. Furthermore, the tools for communication are evolving so fast on the Internet that Web-based communication with the authorities becomes possible. It is possible to use the possibility of sending messages to the other users of the other networks that are connected to the Internet. Students can use various Internet services that are commonly used to reach information resources:

- WWW: It is a distributed information system based on hypertext where you can move from one document to another through links in a document.
- E-Mail: It allows users of a site to send messages to users of other sites.
- Telnet: It is a service allowing people to “login” to another machine on the Internet and execute programs.
- File Transfer Protocol (FTP): It is used to transfer files from one computer to another.

Communication between different sites is possible employing various other platforms such as Usenet, chat rooms and audio or videoconferences.

HTML is a language used for exchange of information that includes 2D images, textual information, video and sound where hyperlinks are used to connect to various other sources on the Internet. It is commonly used for the document layout and also for hyperlink specifications. Although the communication seems to be provided for Internet users with HTML, it needs support for creating 3D scenes (Sanders et al.,

1997). In addition to the static textual and graphical information provided by HTML, VRML can be used to create our own dynamic, flexible sensory-rich VE on the Internet through animating objects, sounds, movies and visual communication mechanisms (Ames et al.,1996).

Nevertheless, VRML is not designed as an HTML extension. VRML can be given as an example for a recent development in use of VE on the Internet. Since it is a powerful description language used for exchange of 3D scenes via Internet in a platform independent way and it is the first 3D user interface for the Web, it seems to be accepted as the standard exchange format for VE on the Internet (Broll and Koop, 1996). The use of other new technologies such as multimedia and hypermedia together with VRML provides opportunities for education, especially for courses that use 3D graphics such as architecture, interior design, graphical design and engineering. Virtual spaces implemented by VRML provide effective use of colour, texture and light which helps the students to construct their design virtually on computer and lets them navigate through it. Furthermore, VRML can be used as a collaborative medium by creating shared spaces for distance teaching or group works. The virtual world created with VRML gives opportunities for geographically distributed students and instructors to have meetings, crits, seminars, lectures and conferences (VRML in Art and Design, 1998). In this way students are not only accessing the information they need but also having the opportunity to meet in social spaces for discussions and group works in virtual environments.

The importance of VE is stressed by director of the Contact Consortium, Bruce Damper as:

“...Creating places where people can meet and interact openly and pursue their passions, will change the future of the world. And we should care about the future, for we shall spend the rest of our lives there. Virtual worlds on the Internet will be the biggest place, human beings have ever made...” (Avatars 97).

Information exchange within such a huge virtual world has created a new point of view for education. In the early times of Web-based communication, WWW and Internet, they were used to exchange information through different networks (Jasnoch et al., 1996). With the integration of multimedia and hypermedia, application areas are enlarged in the following years. Today, Web-based communication is widely used for educational purposes since the essence of both Internet and education is to exchange information. The global information and people whose demands for education are increasing day by day. As a result, many institutions and universities offer Web-based courses for people.

Many educational institutions use Web-based education in order to improve their teaching quality. Some Web applications of these institutions are presented in Chapter 2 and a list of other institutions is given in Appendix A.

1. 4 ORGANIZATION OF THE THESIS

This thesis mainly involves in the use of VE in interior design education using Web-based communication and VRML is investigated. After an evaluation of VE indicating its differences from 3D graphics, an introduction to WWW, HTML and VRML is given in Chapter 1. In Chapter 2, VRML and its implementation basics are

examined. In Chapter 3, Web-based education is introduced, discussing the Web-based education basics and Web-based course design processes. A survey of this field giving sample studies of various universities around the world is also included at this chapter. Chapter 4 contains a proposal about a sample course extension for the senior Interior Design course, Modular Interior Systems, designed within this context. Finally, the future development issues and further research basics that may take place are discussed in Chapter 5, together with the concluding remarks about the subject.

2 VIRTUAL REALITY MODELLING LANGUAGE: VRML

Virtual Reality Modelling Language is an open, extensible industry standard American Standard Code for Information Interchange (ASCII) scene description for 3D worlds on the Internet, which can be shared across platforms such as Unix, MAC or Windows. It is based on Silicon Graphic's (SGI) Open Inventor Format. It allows the author to view distributed interactive 3D worlds or to create 3D worlds such as virtual rooms, buildings, cities or planets on the Internet [Figure 1].

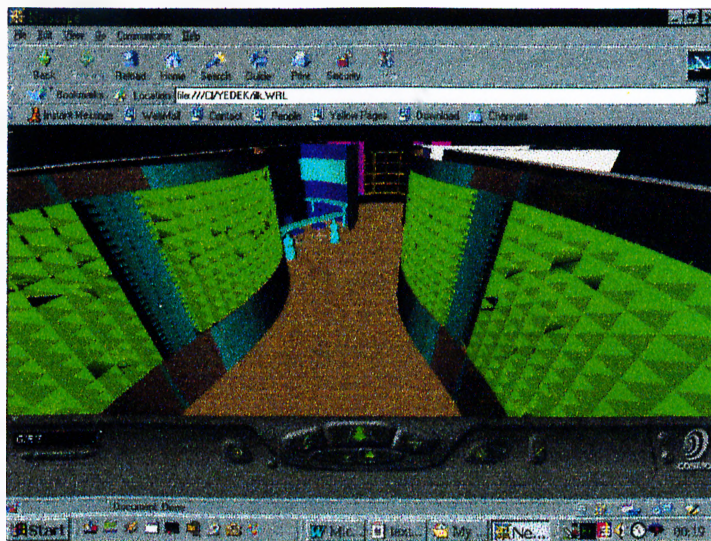


Figure 1: An example for a virtual room created with VRML.

These worlds are dynamic and sensory rich environments and they can provide interaction for people since it is possible to animate objects in the virtual world, play

sounds and add scripts which are small programs that are created to act on the VRML worlds.

2.1 HISTORY OF VRML

VRML was conceived in February 1994 at the first WWW Conference in Geneva, as a result of the need for a 3D-user interface on the Web. The need for tools to have a common language for the specification of the 3D world description and WWW hyperlinks, resulted in the term VRML-Virtual Reality Mark-up Language. Later, in order to emphasise the graphical nature of the language, the word “Modelling” has taken the place of the word “Mark-up” (Hartman and Wernecke, 1998).

An existing file format was chosen by the members of the VRML community, which is SGI Open Inventor, because the ideal format should be accessible and analogous to HTML (Hartman and Wernecke, 1998). Open Inventor is a platform independent system; an object oriented 3D toolkit that enables the control of objects such as trackballs, polygons, materials, cameras and texts. A standard file format is defined for 3D data interchange in Open Inventor. It is built on top of OpenGL, which is a graphics language defining syntax and structure for 3D graphics. The descriptions of 3D scenes created by VRML can be supported with lighting, ambient properties, polygonally rendered objects and realism effects of the Open Inventor Format. Some other existing file formats were also taken into consideration at first, such as CyberSpace Description Format (CDF) by AutoCAD, Labyrinth by Mark Pesce and Toni Parisi, Web Object Oriented Graphics Language (OOGL) by University of Minesotta, and Multi-tasking Extensible Massaging Environment (MEME) by

Immersive Systems Inc. for VRML. However the Open Inventor file format was preferred because Open Inventor's ASCII file format works with HTML (Sanders et al., 1997).

The specifications for the first version of VRML have been developed as a result of discussions through the VRML mailing lists on Web. In this version VRML 1.0, platform independence, extensibility and ability to work well over low -bandwidth connections were provided (VRML 1.0 Specification, 1998)

VRML was presented in the second WWW Conference in October 1994. The first VRML browser, WebSpace Navigator by SGI, was released in 1995. Later on Microsoft and other companies have begun to generate their own versions of VRML browsers (Hartman and Wernecke, 1998).

The VRML Architecture Group (VAG) has been formed by SGI engineers, companies such as AutoDesk, Microsoft, World Inc. and Pesce and Parisi, who are the founders of VRML. VAG presented the specifications of the version 2.0 of VRML at Siggraph'96 in New Orleans. In 1997, the attendees of the Avatar Conference held in 1997 focused on the creation of the communities on the Web. Parallel to the developments, artists, engineers and developers demonstrated their products and expressed their ideas and beliefs about the structure of the virtual world in cyberspace (Avatars, 1997).

2.2 CREATING VRML WORLDS

Virtual worlds can be created via VRML through various ways:

- VRML text files,
- Authoring packages,
- Conversion programs.

A textual description of the virtual world can be created with the help of a text editor or word processor in Open Inventor Format. This textual description is called a “VRML File” [Figures 2, 3]. VRML file names have the “.wrl” extension by default, indicating that the file contains a VRML statements in the Open Inventor file format describing a virtual environment.

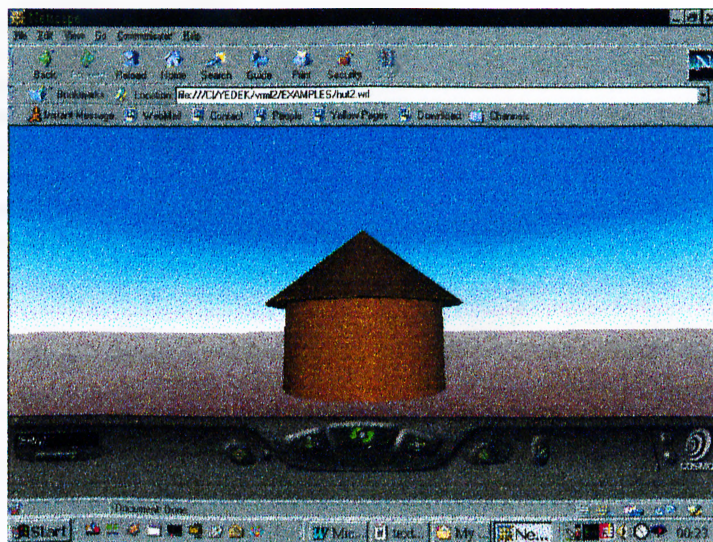


Figure 2: A VRML world example.

```

#VRML 2.0 utf8
Background {
  skyColor [
    0.0 0.2 0.7,
    0.0 0.5 1.0,
    1.0 1.0 1.0
  ]
  skyAngle [ 1.309,1.571 ]
  groundColor [
    0.1 0.10 0.0,
    0.4 0.25 0.2,
    0.6 0.60 0.6,
  ]
  groundAngle [ 1.309 1.571 ]
}
# A brown hut
Group {
  children [
    # Draw the hut walls
    Shape {
      appearance DEF Brown Appearance {
        material Material {
          diffuseColor 0.6 0.4 0.0
        }
      }
      geometry Cylinder {
        height 2.0
        radius 2.0
      }
    },
    # Draw the hut roof
    Transform {
      translation 0.0 2.0 0.0
      children Shape {
        appearance USE Brown
        geometry Cone {
          height 2.0
          bottomRadius 2.5
        }
      }
    }
  ]
}

```

Figure 3: The VRML Code for the drawing in Figure 2.

In order to experience these worlds, a browser that interprets VRML files is needed, where browsers may exist as plug-ins for HTML browsers [Figure 4] or stand-alone VRML browsers.

```

#VRML 2.0 utf8
Background {
  skyColor [
    0.0 0.2 0.7,
    0.0 0.5 1.0,
    1.0 1.0 1.0
  ]
  skyAngle [ 1.309,1.571 ]
  groundColor [
    0.1 0.10 0.0,
    0.4 0.25 0.2,
    0.6 0.60 0.6,
  ]
  groundAngle [ 1.309 1.571 ]
}
# A brown hut
Group {
  children [
    # Draw the hut walls
    Shape {
      appearance DEF Brown Appearance {
        material Material {
          diffuseColor 0.6 0.4 0.0
        }
      }
      geometry Cylinder {
        height 2.0
        radius 2.0
      }
    },
    # Draw the hut roof
    Transform {
      translation 0.0 2.0 0.0
      children Shape {
        appearance USE Brown
        geometry Cone {
          height 2.0
          bottomRadius 2.5
        }
      }
    }
  ]
}

```

Figure 3: The VRML Code for the drawing in Figure 2.

In order to experience these worlds, a browser that interprets VRML files is needed, where browsers may exist as plug-ins for HTML browsers [Figure 4] or stand-alone VRML browsers.

In addition to creating textual VRML files, also conversion programs for translating commonly used 3D file formats into VRML exist.

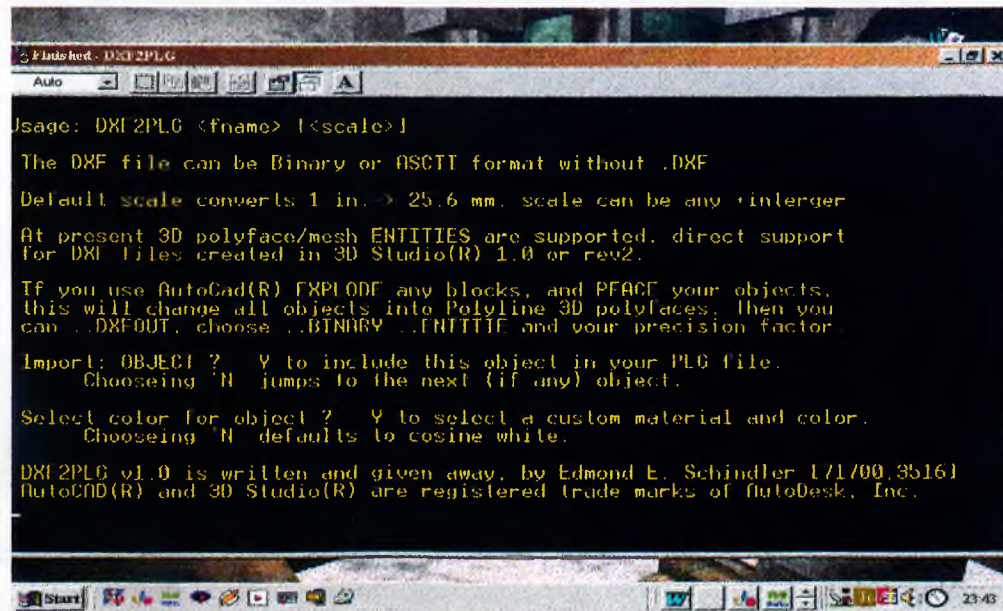


Figure 4: An example plug-in for conversion of DXF files.

Authoring packages enable building the models and positioning them within the virtual world. Figure 5 shows the authoring package of 3Dview (3Dview).

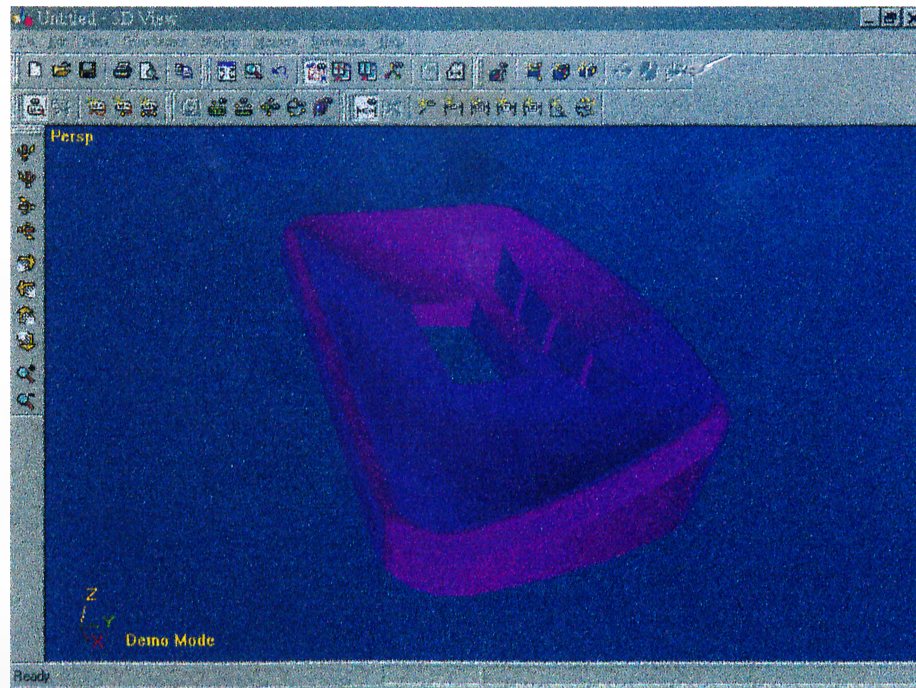


Figure 5: An example for Authoring Package, 3DView.

Conversion programs on the other hand, convert the non-VRML 3D drawing files generated by AutoCAD or 3D StudioMAX with the extensions “.dwg”, “.dxf”, “.3ds” to VRML files with the extension “.wrl” [Figures 6, 7] (Miller, 1997).

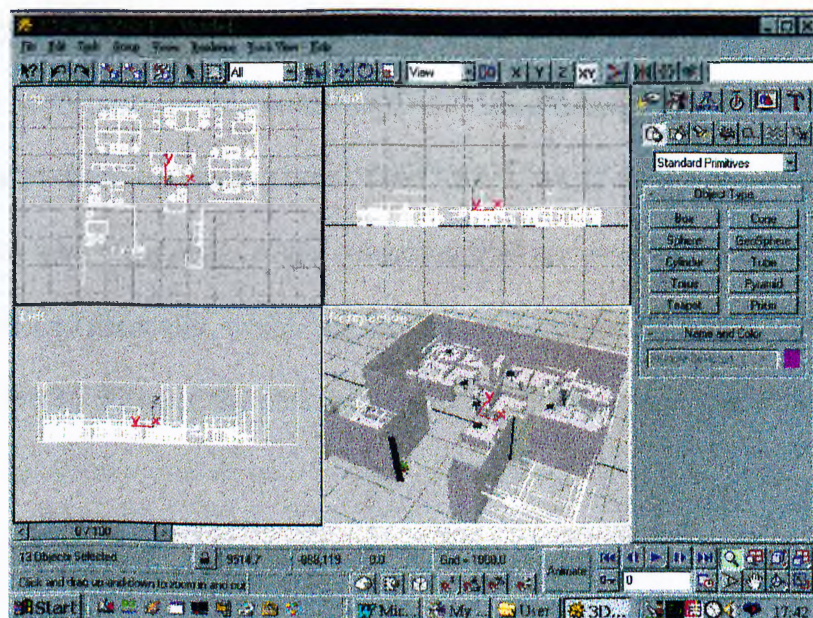


Figure 6: An office design drawn in 3DStudioMAX.

2.3 VRML OPERATIONS

Virtual Reality Systems provide interaction with the objects in the virtual environment. In such a system, it is possible to create and manipulate objects and communicate with other VR users within the VE. VRML is used as a tool to describe these interactive 3D objects or worlds. VRML is employed by various disciplines like engineering, architecture and education for multimedia presentations and entertainment over the Internet or the Local Client System.

The objects in the VRML world are created by using shapes, which are the building blocks of a VRML world. Shapes are defined by specifying geometric model, colour, material and surface properties. For a more realistic sense of the virtual world, texture mapping, animations, special effects such as fog, light and sound can be added. Navigation is also possible with the control over the avatar, which is the 3D figure that represents the user.

In the design and creation of a VRML world, some technical and graphical considerations are important. On the one hand, just like the factors that effects the quality of a HTML document such as processing speed of the server and client system, transmission bandwidth and browser capabilities should also be considered when working with VRML worlds. On the other hand, the elements that are used in the web page such as polygons, texture, level of detail, inlines and compression, also effect the performance of the web page (Ames et al., 1996).

VRML worlds enable arbitrarily large dynamic 3D worlds. The size of the VRML file effects the rendering time. Simple structures in object creation should be preferred due to the speed consideration in displaying virtual worlds. Also, the

availability of the reusability of an existing object is an important issue. Moreover, inline files can be created by pulling other available VRML files into one's own VRML file. In these ways, it is possible to keep the size of VRML file relatively small, rendering time short and a high performance on displaying of the objects.

In addition to controlling of the size of the objects in the world, the rendering performance can be increased and the rendering time can be shortened if the selective refinement property of the VRML worlds is used. The meaning of selective refinement is that VRML has the ability to download portions of the scene from the Web server independently so that sections of the scene can be selectively refined when you get closer to see the details.

Another factor for the rendering time is related with the details of the VRML world. VRML allows some browsers to select different levels of details to improve the speed of rendering time. Realistic simulations and special effects are possible in the VRML world with the help of Level of Detail (LOD). In detailing, small textured images to be mapped over the shapes are also recommended.

Hyperlinks can be applied in VRML worlds. Objects in the VRML world can be hyperlinked to other VRML files, web pages, or other hyper-media such as text, sound, image or movie. For instance, when the cursor is held on an object, the object is highlighted and clicking on it can activate the object.

```

<HTML>
<HEAD>
  <META HTTP-EQUIV="Content-Type" CONTENT="text/html; charset=iso-8859-1">
  <META NAME="Author" CONTENT="aysu">
  <META NAME="GENERATOR" CONTENT="Mozilla/4.05 [en] (Win95; I) [Netscape]">
  <TITLE>CLASS</TITLE>
</HEAD>
<BODY TEXT="#CCFFFF" BGCOLOR="#000099" LINK="#33CCFF" VLINK="#3333FF"
ALINK="#3366FF" BACKGROUND="Bg22.JPG">
<CENTER><IMG SRC="dividerb.gif" HEIGHT=52 WIDTH=714></CENTER>
<CENTER><B><FONT COLOR="#98D6BD"><FONT SIZE=+3>OFFICE
DESIGN</FONT></B></CENTER>
<CENTER><IMG SRC="Contline.gif" HEIGHT=5 WIDTH=536></CENTER>
&nbsp;
<CENTER>&nbsp;<EMBED SRC="mod.wrl" WIDTH="417" HEIGHT="251"></CENTER>
&nbsp;
<BR>&nbsp;
<BR>&nbsp;
<BR>&nbsp;
</BODY>
</HTML>

```

Figure 8: HTML Code of Figure 34, incorporating a VRML world.

Additionally, VRML worlds can be embedded into HTML files [Figures 34, 40, 41 and 43]. In order to embed a VRML file to a HTML source, the width and the height of the VRML view should be defined in the HTML code [Figure 8]. This provides a dynamic relation between other media.

In order to construct a VRML file using these properties, a basic information about VRML concepts and elements will be discussed in the next section.

2.3.1 VRML COMPONENTS

As mentioned before, the textual description of a VRML world is formed as VRML file. A VRML file is formed of six main types of components:

- VRML Header: This is required in the first line of every VRML file indicating the version of a VRML file that uses the international UTF-8 character set [Figure 9].

```
#VRML V2.0 utf8
```

Figure 9: VRML Header

- Prototypes: The prototype definition enables one to define the name, field, exposed fields, events and the node body of the node type.
- Interpolators: These are used to define a piecewise linear interpolation of a particular type of value at specified times.
- Sensors: These enable the user to interact with the world in the scene graph hierarchy. Sensor nodes respond to the user interaction with geometric objects in the world, the movement of the user through the world, or the passage of the time.
- Scripts: It is possible to create or refer to a script, which is a program, written in a language, such as Java or Perl.
- Routes: These are the connections between a node generating an event and a node receiving the event.

VRML file can also contain comments, nodes, defined/used node names and fields with or without field values. New node types can be created by using a prototype definition. It is possible to build a library of one's own new node types to keep in a separate VRML file. The basic concepts to create VRML files using these elements can be seen below.

2.3.1.1 CREATING SHAPES

In a VRML world, the basic building blocks are the shapes that are defined by nodes and fields. Polygons are used to create shapes in a VRML world. The shape has geometry, appearance based on material, colour and surface defining texture. Similar to the instructions for the building of a real world, VRML world instructions include precise sizes and distances. Shapes are built using the Shape Node by specifying the geometry and appearance of the shape. They are always created relative to the origin which is located at the center of the scene. This system employs the right handed Cartesian Coordinate System for modifications of VRML worlds, which are 3D virtual spaces. The X-axis is described from left to right Y-axis from bottom to top, and Z-axis from the space towards the viewer.

Basically, VRML handles the following simple shapes:

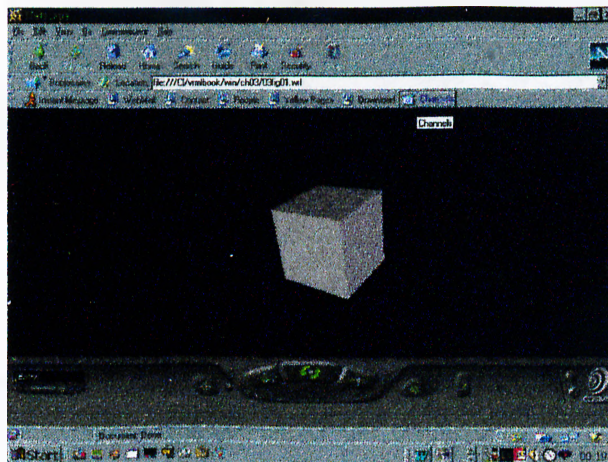


Figure 10: VRML view of a cube.

```
#VRML V2.0 utf8
Shape {
  appearance Appearance {
    material Material { }
  }
  geometry Box { }
```

Figure 11: The VRML code of the cube in Figure 10.

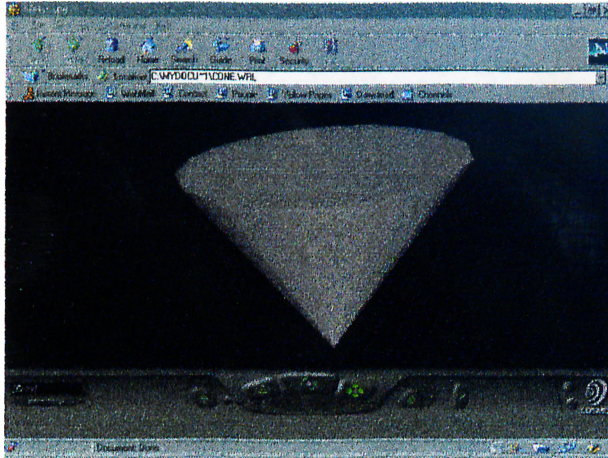


Figure 12: VRML view of a cone.

```
#VRML V2.0 utf8
Shape {
  appearance Appearance {
    material Material { }
  }
  geometry Cone { }
```

Figure 13: The VRML code of the cone in Figure 12.

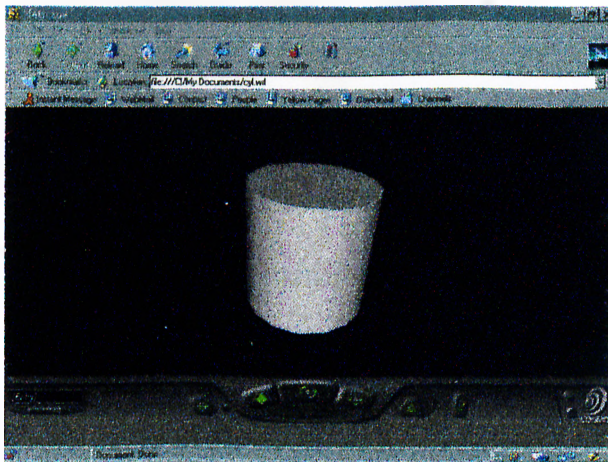


Figure 14: VRML view of a cylinder.

```
#VRML V2.0 utf8
Shape {
  appearance Appearance {
    material Material { }
  }
  geometry Cylinder { }
```

Figure 15: The VRML code of the cylinder in Figure 14.

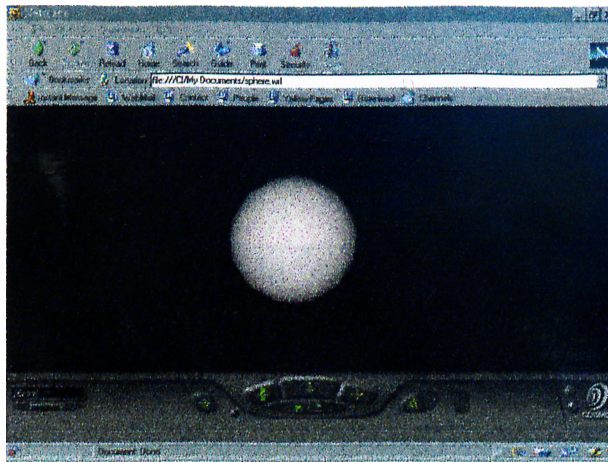


Figure 16: VRML view of a sphere.

```
#VRML V2.0 utf8
Shape {
  appearance Appearance {
    material Material { }
  }
  geometry Sphere { }
}
```

Figure 17: The VRML code of the sphere in Figure 16.

VRML supports many other primitive geometric shapes such as extruded shapes or elevation grids. This geometry can be used to build larger or more complex shapes since shapes can be grouped. The node grouping some shapes together is called the “parent” and the shapes that are part of the group are called the group’s “children”. When a group is contained within a larger group, then it is considered to be nested within the larger group (Ames et al.,1996).

In order to make the world dynamic, wiring instructions may be used. For instance, it is possible to click on a shape in the world with the mouse to turn on a light or activate a machine (Ames et al.,1996). Circuits may also be constructed by building routes between nodes. VRML wiring involves a pair of nodes to wire together and a wiring route (path) between them. The message that is sent by the first object to the second one is called the "event". Events may contain a value just like field values

within the nodes. The type of reaction depends on the type of node receiving the event, the node input jack to which the route is wired, the values contained in the event and the current activities of the node (Ames et al., 1996).

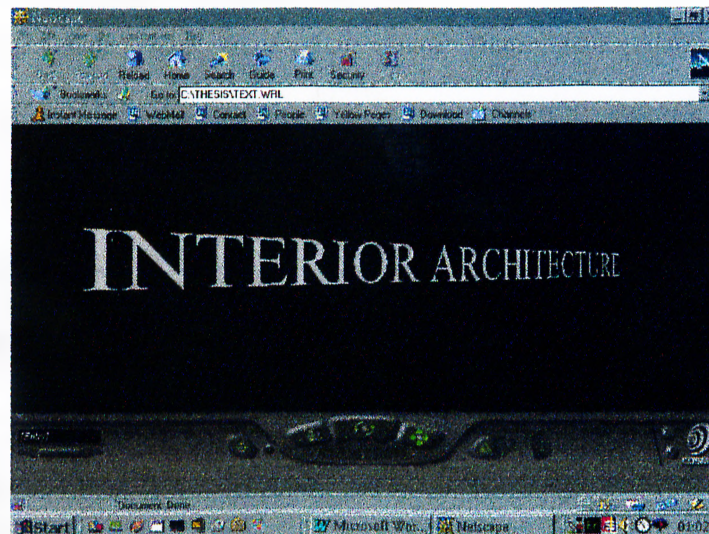


Figure 18: An example for a text shape.

```
#VRML V2.0 utf8
Shape {
  appearance Appearance {
    material Material { }
  }
  geometry Text {
    string "INTERIOR ARCHITECTURE"
  }
}
```

Figure 19: The VRML Code of Figure 18.

In VRML, it is possible to manipulate the text and font features [Figure 18, 19]. Text Node is used for value of Shape Node's geometry field. Using the FontStyle can control font family, style, size of the text geometry, spacing, justification and flow direction.

2.3.1.2 POSITIONING SHAPES

The world coordinate system is constructed automatically by the VRML browser.

The shapes or text shapes can be positioned anywhere in the world. They can be stacked on top of each other, inside each other or placed in mid air [Figure 2].

Transform grouping node and translation fields are used for this purpose (Ames et al., 1996). A new coordinate system is created relative to its parent coordinate system by the Transform Node. Transform Node collects a group of child nodes. Shapes built by these child nodes are built at the origin within the Transform Node's coordinate system. If that coordinate system is repositioned, all of the Transform Node's children are repositioned along with the coordinate system. A VRML file may contain any number of nested child coordinate systems, each one positioned relative to its parent's coordinate system (Ames et al., 1996).

The new coordinate system can be rotated relative to its parent's coordinate system by using the rotation field of the Transform Node. This value specifies a rotation axis, which is an imaginary line and a rotation angle measured in radians [Figures 20, 21]. The rotation occurs around either X, Y, or Z-axis however arbitrary diagonal rotation axes can also be specified. Centre field controls the centre of rotation for orienting the coordinate system (Ames et al., 1996).

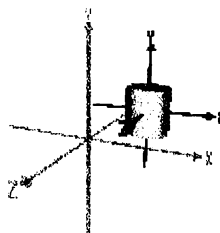


Figure 20: An example for rotating a cylinder
(VRML 2.0 Source Book CDROM)


```

#VRML V2.0 utf8
Transform {
  translation 2.0 1.0 -2.0
  children [
    Shape {
      appearance Appearance {
        material Material { }
      }
      geometry Cylinder { }
    }
  ]
}

```

Figure 21: The VRML Code of Figure 20.

The new coordinate system can also be scaled relative to its parent's coordinate system by using the scale field of the Transform Node. This value specifies three factors to increase or decrease the size of the coordinate system. In order to create shrunken or grown shapes, same scale factors for all three dimensions or different scale factors for each X, Y, and Z dimensions can be used. Diagonal directions can be scaled by rotating the scaling directions (Ames et al.,1996).

2.3.1.3 MATERIALS AND TEXTURE MAPPING

The visual detail of the real world is known as texture in computer graphics. Since creating these visual details can be time consuming and difficult, VRML enables mapping a scanned picture of anything on the shapes in the VRML world. For instance, it is possible to map a brick image on the wall in a VRML world [Figures 22, 23]. Only, if they are viewed from very close, illusion breaks may occur.

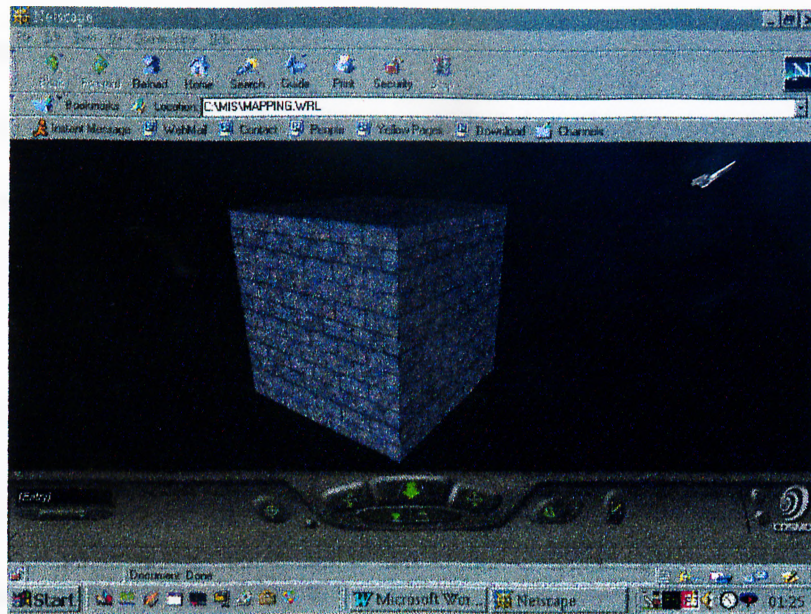


Figure 22: An example for texture mapping in VRML

```
#VRML V2.0 utf8
Shape {
  appearance Appearance {
    material Material { }
    texture ImageTexture {
      url "Brick06.jpg"
    }
    textureTransform TextureTransform {
      scale 3.0 3.0
    }
  }
  geometry Box { }
```

Figure 23: The VRML Code of the drawing in Figure 22.

VRML supports four most commonly used image file formats JPEG, GIF, PNG, and MPEG for texture mapping. It is also possible to specify the pixel values explicitly, one by one for an image. In this way, there is no need to store the image in a separate file since a texture image is embedded in the VRML world (Ames et al., 1996).

Apart from the texture mapping, the material of a shape can be controlled as well as the appearance, such as shape's colour, glow colour, or transparency factor (Sanders

et al., 1997). Moreover shading is provided by using the values of normals which are the orientation of a face used to determine how brightly to shade a face (Ames et al., 1996). In order to visualise these properties, lighting plays an important role in VRML worlds.

2.3.1.4 LIGHTING

Lighting is an important factor in the VRML world since creative lighting increases the realism of the world. Lights of the VRML world are used to brighten a scene and highlight point of interest, just like they are used in the real world. In this sense, various lighting effects are possible through various light sources.

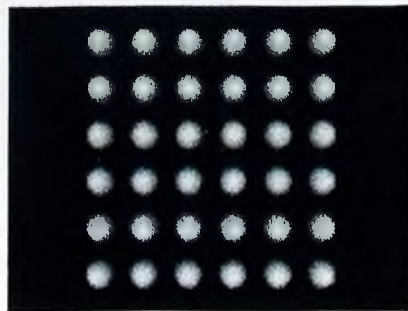


Figure 24: An example for headlight
(VRML 2.0 Source Book CDROM).

Headlights are added automatically into the VRML world and controlled by the VRML browser in order to illuminate anything in front of the viewer. Figure 24 shows an array of spheres illuminated by a headlight.

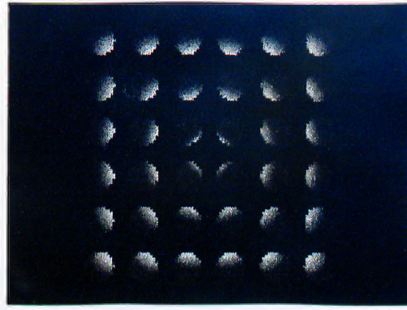


Figure 25: An example for point light directed from the top (VRML 2.0 Source Book CDROM).

Point Lights, Directional Lights and spotlights can be used additionally. Point lights create light in radial pattern in all directions as if the light rays are coming from a single point source [Figure 25].

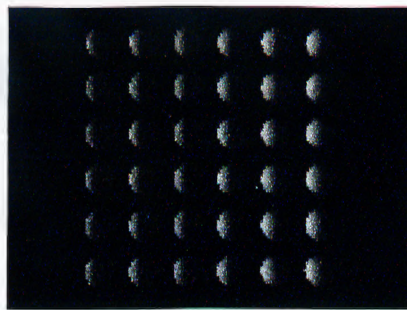


Figure 26: An example for parallel light directed from left (VRML 2.0 Source Book CDROM).

Parallel light rays, similar to sunlight rays, are also provided by directional light. A direction should be defined for this type of light [Figure 26]. Spotlights, on the other hand, are aimed in a specific direction, creating a light cone. Only the shapes within that light cone are illuminated.



Figure 27: A virtual world created with coloured directional light (VRML 2.0 Source Book CDROM)

```
#VRML V2.0 utf8
Group {
  children [
    DirectionalLight {
      direction 0.8 -0.2 -0.2
      intensity 1.0
      ambientIntensity 0.3
      color 1.0 0.6 0.0
    },
    # Vaulted ceiling and columns
    Inline {
      url "vaulted.wrl"
      bboxCenter 0.0 1.0 0.0
      bboxSize 6.0 2.0 6.0
    },
    # Floor
    Shape {
      appearance Appearance {
        material Material { }
      }
      geometry Box { size 16.0 0.01 16.0 }
    }
  ]
}
```

Figure 28: The VRML Code of the drawing in Figure 27.

Ambient light that is a result of scattering and reflection of light around a room can also be simulated and controlled in VRML world in order to create different atmospheres.

The colours of light that are absorbed or reflected by a surface determine the colour of the surfaces. In a VRML world, only the colour of point lights, directional lights and spotlights may be changed in order to create lighting effects [Figures 27, 28]. It is possible to use multiple lights, which can be of similar or different types, location and colour.

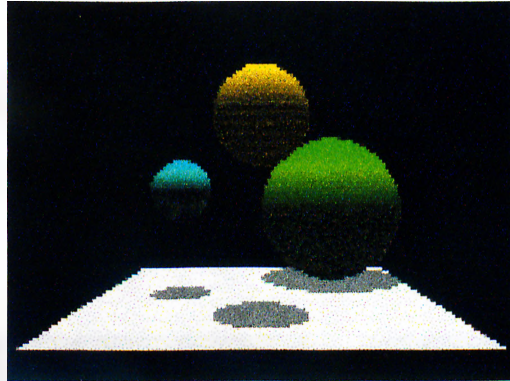


Figure 29: An example for casting shadows in VRML world (VRML 2.0 Source Book CDROM)

Although shapes cast shadow when they block the light rays in the real world, VRML worlds does not provide this property since shadow computation is quite a time consuming and complicated operation to perform interactively. However a light can illuminate a shape even if it is behind another one because light travels straight through shapes in VRML worlds. In order to break down the ambiguous and odd composition of VRML worlds, it is recommended to create fake shadows by creating black semitransparent faces positioned at the places where the object would cast shadow [Figure 29] (Hartman and Wernecke, 1998).

2.3.1.5 ANIMATION AND NAVIGATION

VRML worlds enable movement by animating position, orientation and scale of any coordinate system. When the coordinate system moves, all the shapes built within this coordinate system moves together [Figure 30] (Hartman and Wernecke, 1998). A clock is created to control the animation by TimeSensor Node. The times at which the time sensor starts and stops are set for the animation. Once started, the sensor loops through a cycle or multiple cycles based on the value of the loop field (Ames et al., 1996).

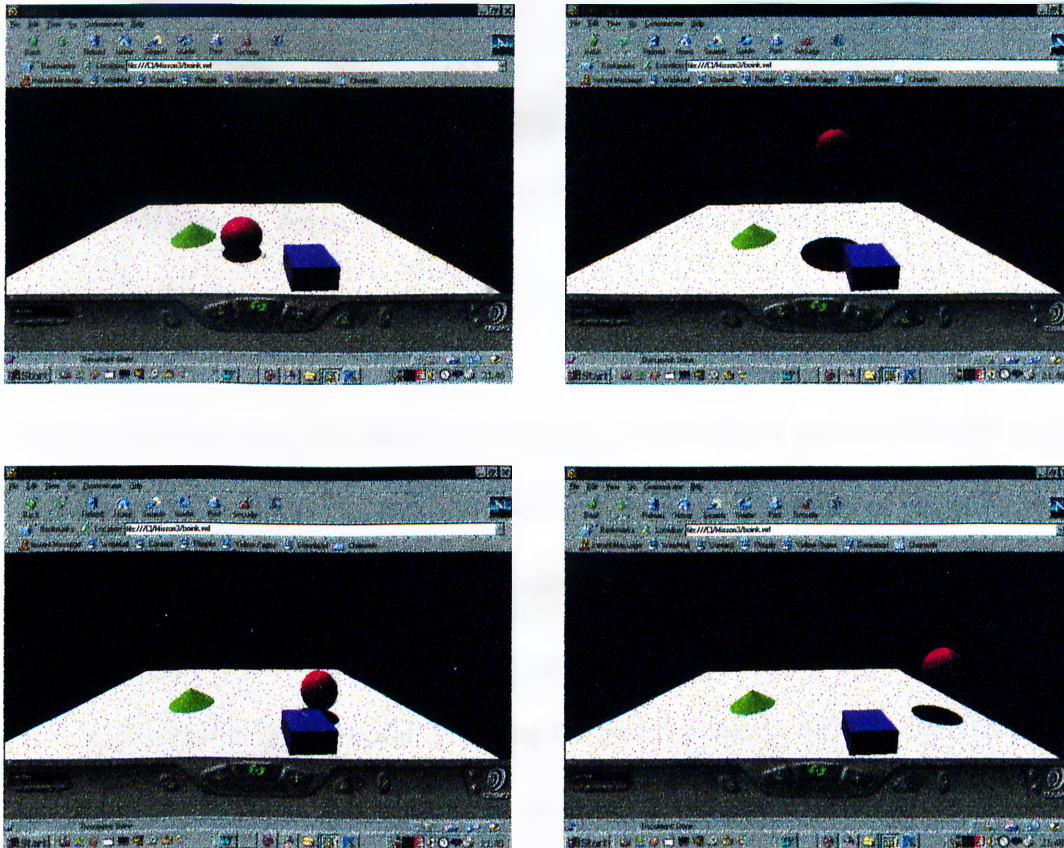


Figure 30: An example for an animation process.

Navigation is also possible in VRML worlds. The NavigationInfo Node describes the characteristics of an avatar, which is an image within the VRML world that represents the viewer [Figure 31].

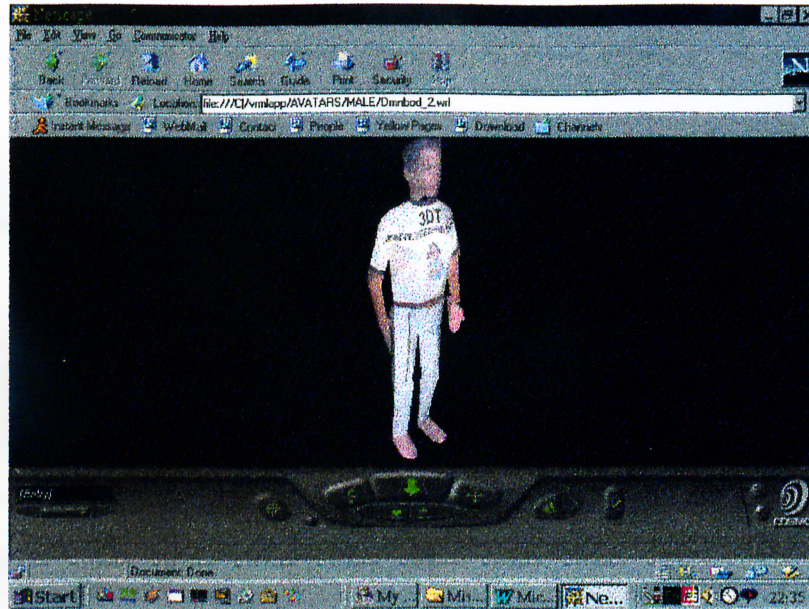


Figure 31: An example for an Avatar (Cosmo Player)

The size of the avatar, the speed of the avatar, the headlight provided for the avatar and the visibility limits can be controlled and changed. The scale of visibility limits, size and speed changes relative to the coordinate system of the current viewpoint. The type field specifies how the viewer can move within the world by walking, flying, or examining the world. Walking follows the terrain and is subjected to gravity whereas flying ignores gravity and does not follow the terrain.

2.3.1.6 SOUND

In the first version of VRML, the only way to play a sound was by linking to a sound file. However, VRML2.0 enables us to present sound within a VRML file (Sanders et al., 1997).

```
#VRML V2.0 utf8
Group {
  children [
    # Sound emitter
    Sound {
      source DEF Source AudioClip {
        url "tone1.wav"
        loop FALSE
      }
      minFront 5.0
      minBack 5.0
      maxFront 10.0
      maxBack 10.0
    },
    # Sound emitter markers
    Inline { url "sndmark.wrl" },
    # Sensor
    DEF Touch TouchSensor { }
  ]
}
ROUTE Touch.touchTime TO Source.set_startTime
```

Figure 32: An example for a VRML code containing sound
(VRML 2.0 Source Book CDROM)

Using the sound node, it is possible to locate sound at a certain point or cause it to emit noise in a specific pattern (Hartman and Wernecke, 1998). Moreover, background noises, speech, music, special effects or multiple sounds can be added to a VRML file for a more realistic effect.

Sound node is used to control the intensity, direction and location of the sound source. A sound emitter is specified within the sound node, which selects a sound source described by AudioClip node or MovieTexture Node. Figure 32 shows an example of VRML world with sound triggered by touching a set of emitter markers.

The AudioClip node on the other hand, selects the WAV digital sound file or a MIDI file for playback as a sound source (Ames et al., 1996).

2.3.2 VRML STANDARDS AND SPECIFICATIONS

The capabilities, specifications and standards of VRML are evolving due to the studies of VAG from time to time. The first version, VRML 1.0 was designed to support the platform independence, extensibility and ability to work over low bandwidth connection. However, it is possible to make only simple animations using VRML 1.0 while VRML 2.0 supports complex 3D animations, simulations and Java language and scripts that can be used with VRML objects (Hartman and Wernecke, 1998). The changes in specifications and standards of VRML 1.0, VRML 2.0 and new versions of the future can be followed from the Internet:

VRML Repository (<http://www.sdsc.edu/vrml>)

Web3D Consortium (<http://www.web3D.org>)

2.4 VRML TOOLS

VRML tools such as browsers, editors, converters, plug-ins are also being developed to help viewing, creating and editing virtual worlds by companies such as Autodesk, Silicon Graphics, Sony, Platinum Technology, Virtus and Intervista. Most of these companies are working on the new versions of their products every day. In Appendix B, a list of recently developed and commonly known VRML tools is given.

In the next chapter, Web-based education basics are discussed where VRML plays an important role together with HTML in such a new platform.

3 WEB-BASED EDUCATION

Exchange of information is the essence of education supported by various tools evolving with the technological developments, and recently applying modern computer communication systems. The use of computers for information exchange accelerated with the use of Internet and WWW has become a part of the global communication. Related to this concept, the technological developments for Web-based education have been founded around 1960s (Baker, 1994). A personal computer or terminal, a modem, a telephone or a network connection and basic communication software are used for offering a Web-based course. Although some experimental Web-based courses were prepared in 1970s, Web-based degree programs and the experimental offerings took place in early 1980s due to the widespread use of personal computers and modems (Baker, 1994). Recently, technological developments support the increasing interest in higher education and lifetime learning on the Internet.

There are many distance education programs all around the world such as Open University in Great Britain, Norwegian Association for Distance Education in Norway, Michigan State University and Electronic University Network in USA and many others in Japan, Denmark, and other countries. Examples like these Web-based education programs provide opportunities to an access a university program or a

higher education program, allowing a lifetime learning or recarriering opportunities for people all around the world.

In a Web-based course, a virtual environment is created on the WWW to provide communication between students and instructors about learning related tasks. It is not limited to only distributing information to the students but also it includes tasks such as student assessment and class management (Jones and McCormack, 1996).

Web-based education integrates direct feedback and group communication to enrich the overall learning experience in addition to the motivation for self -study. It provides opportunities for self-directed learning since the levels of education can be completed without time constraints. Moreover, it offers education for students who would otherwise be inhibited from attending an educational program because of physical, geographical or time related reasons. It provides a number of application options that allow the programs to be adapted to people with disabilities, desperate learning needs and different learning styles.

In order to construct a Web-based classroom, technical and educational principles should be experienced so that, education methodologies may be adopted due to the improvements in technology. Also, time, support and training should be provided by the instructors to implement a Web-based classroom.

3.1 WEB-BASED EDUCATION BASICS

Building a Web-based classroom is not a simple and quick process. However most instructors aims to use this new teaching process because it has many advantages over the traditional teaching process.

Today, students require much more resources, attention and feedback in their education. Also, as the amount of resources generated by the new knowledge is increasing, day by day, people need advanced training in specific fields.

As a result, nowadays, there is an increase in the number of participants in education and training sectors. This causes an increase in class sizes, higher student-to-instructor ratios and a decrease in student-to-instructor interaction. Thus, the motivation of the student is reduced and the participation of the students in the lectures is decreased. Parallel to the increasing population of the students, variations in the characteristics of the students are also increasing. Student backgrounds, cultures, previous learning experiences, preferred learning styles and personal situations differ from each other. In this case, flexibility in education is necessary. Web-based education provides this flexibility in education by reducing the time and place constraints. This flexibility is beneficial especially for the disabled students because the disabled student do not have to attend the class physically. For instance, visual data for students with hearing disability and audile data for the students with visual disability, provided in Web-based education with multimedia tools can be given as examples. However, participants to the Web-based course should be trained to adapt to the changes, in addition to getting familiar with the current knowledge. In order to satisfy these needs, educational institutions need to improve the quality of their services, and offered Web-based courses.

3.2 ADVANTAGES AND DISADVANTAGES OF WEB-BASED EDUCATION

Expectations of students from being educated change depending on the personality of the student. Web-based education offers solutions for most of these problems as a result of its special characteristics. Some of the benefits of Web-based classroom can be listed as follows:

- The power of computer in storing, indexing, searching, converting and distributing information can be adapted to improve the quality of the courses since the student can have a control over the learning process contrary to the traditional teaching process. For instance, a growing archive for a course may be recorded to be used in the future. Mailing lists, news groups, or forums for the class and FAQ (Frequently Asked Questions) lists can also be used for the exchange of information. In addition, the student records can be recorded as well as learning materials.
- Learning and teaching are not restricted to physical buildings in Web-based education. Students study what they need wherever they want, at any time (Graves, 1996). The course material becomes available as soon as it is placed on the Web. It can be modified depending on the requirements, needs and responses of the students. In this way, students may have more control over the education process, which would increase their motivation to study and research.
- When the distribution of information through Web is combined with the asynchronous communication and appropriate pedagogical issues, educational flexibility can be achieved to reduce the time constraints. In this way, participants do not miss a class and students no longer compete for instructor's limited time. Both

the student and the instructor may have the flexibility in time arrangement for responses (Jones and McCormack, 1996).

- Parallel to the developing technology, people become more familiar with the computer and Internet. Even if the student does not have any experience on the Internet, the tools that are applied to participate within a Web-based course are quite simple to use, having guiding explanations. By directing the students to learn Internet facilities, they are also familiarised with this new media which would be used in their daily life apart from education (Jones and McCormack, 1996).
- The use of e-mail, chat programs, or forum facilities on the Internet allows the participant to communicate with others individually or in groups. In this way questions are issued and conversations are conducted, oral and electronically. Since people find the communication through Internet more comfortable than face-to-face communication, they interact with more people to see different points of views (Jones and McCormack, 1996).

Bringing all these advantages together increases attention of the students over the learning material. In this way, they choose the form of learning activity that is most appropriate for them.

Nevertheless, Web-based education should not be seen as a solution to every problem that an instructor can face with the class. There are some limitations that can be faced in a Web-based course such as:

- In the Web-based education, the technological developments should be combined with pedagogy to increase the quality of the education (Jones and McCormack, 1996). Both instructors and students may have problems if they are only

experienced with traditional didactic teaching methods. On the one hand, the students should be aware that they could no longer remain passive participants to the class. On the other hand, the instructor should adapt the technological developments to the course for an effective teaching.

- Although it is an easy medium to use and most of the students are familiar with Internet now, the special rules and regulations of the Web should be taught to the students who are not familiar with the Internet, so that they feel comfortable with this new virtual environment. For instance, a list of rules and regulations can be included in the information page of the Web-based course.
- Lack of physical cues may be uncomfortable for the instructor. Also face-to-face interaction is eliminated between the participants in a Web-based course, which is a disadvantage for architectural design education. However, the level of interaction is not just related to the face-to-face interaction but related to the method of teaching. A great deal of interaction may be provided if the instructor encourages students for group discussions or group works. Also, a system for virtual desk crits can be constructed similar to a project in Massachusetts Institute of Technology (MIT) (Mitchell, 1998). Simply, it is highly related to the instructor's approach (Jones and McCormack, 1996).
- Providing the computer with required properties and access to the Internet are not easy for every one due to the economical problems and technological advances. Accessing the technical components may be difficult and time consuming to many participants. So, even if we assume that the tools needed to participate a Web-based course and the Internet access is available, the design of the course should be as simple as possible in order to reach a large number of participant.

- Students and institutes also face with the cost problems. The cost of building a Web-based classroom would be too expensive in terms of time, money and resources for the institute. Although Web is at no charge for on campus students, many students may want to work at home, which would make a cost of money based on the usage. So charging based on usage can make students anxious to study enough on line because the use of personal computer by the student may increase the expense of the student. However, institutes may save money in this way. This cost saving by the institutions may be used to provide additional benefits for the student's education (Jones and McCormack, 1996).
- The reliability of information on the Internet creates another problem. Since Internet is a new medium, the amount of information is still limited and the reliability of all sites is not satisfactory (Jones and McCormack, 1996).
- Issues of copyright, privacy, security and authentication are still a problem for both Web-based and traditional classrooms since laws do not exist, yet (Jones and McCormack, 1996). Also the question of how to know that the student submitted the assignment really prepared it himself arises in some cases since existing information on the Web can make cheating easier, some other assessment methods may be adapted to make cheating difficult.
- The technical background for the instructor is necessary in addition to the educational principles because it would be quite difficult to implement an effective and efficient Web-based education without technical background. However the instructor should be careful to stress on the educational or technical principles, since a project applying high technology may still fail to serve their educational purposes.

In order to reduce these problems, a development in the strategy to define Web-based education is necessary. Recently, there have been many researches to build up an evolutionary strategy to define Web-based education. For instance, according to the specifications defined in the Monterey Conference, the Web-based higher education would require an advanced structure capable of supporting desktop and room based conference, incorporating and integrating voice traffic and exchanging huge amounts of projects (Graves, 1996). A systematic and proper planning of these problems may diminish the lack of face to face communication, which is the most obvious problem of Web-based education.

3.3 COURSE DESIGN PROCESS

The use of computer based training, computer managed learning and CD-ROM applications have revolutionised the education process. However, there is a variation in the needs and requirements of the students and instructors, so there is not only one correct way to do it but a collection of rules or principles can be used to guide the creation of Web-based education systems (Jones and McCormack, 1996). Using these principles and rules, the instructor can shape the Web-based classroom, the way it best suits the participants and the nature of the course. The design of the Web-based course is quite critical in this sense because an inappropriate design may cause the quality of the education to fail.

The most important point in Web-based education is that it can not replace the role of the instructor. For this reason, it is just a new form of educational tool. It is most suitable for learner centred studies. Students are encouraged to take more control of

their own education in a Web-based course when the course information is available for the students any time and have a possibility to communicate with the other members of the class. It is possible to use Web-based education in two ways. Currently, the most common approach is to use it to support the existing traditional teaching methods. Another way is to replace the existing method completely with the Web-based course.

Integrating Internet possibilities into the traditional teaching methods provides many advantages for both the student and the instructor. From, students' s point of view, since the lecture notes, FAQ, assignments and self-study experiments for students can be accessed over the Web, they have no time or place constraint to read and study lecture notes and conduct the experiments. Common problems are answered through the FAQ so that they do not spend time to ask and wait for reply or make a research on the task. Communicating on the Web using audio or video conferencing, chat, Newsgroups or forums also helps the students to discuss the tasks in wide groups without any place constraint.

The instructors, in a way, design the learning experience when preparing a Web-based course with the technological advances. Course planning and design is a complex process when it is to be implemented on the Web. Following a systematic program can only shape the structure and the appearance of a well-defined Web-based education.

3.3.1 DEFINING THE SCOPE OF THE COURSE

The process of designing a Web-based course starts by defining the scope of the course. The information that will be given in the course should be well defined. Lists of educational goals should be prepared because Web-based classroom should be directed to its purpose only. In this step the technology and practical issues should not restrict the instructor (Jones and McCormack, 1996). While defining the goals, in addition to the previous experiences of the instructor, other examples of the same or similar courses can be observed because different perspective would be useful to identify the advantages and disadvantages of the teaching methods.

3.3.2 TEACHING METHODS

In the second step, practical issues are considered. The instructor should decide how the course would be taught and how the student will follow it on the Web related to the nature of the course and availability of Internet possibilities without discarding of technological advances. The existing methods may be used but they should not restrict the instructor. The technological developments should be investigated to prepare an effective and efficient course. However, it is important to use applicable methods related to the course and class characteristics because using complicated technical and educational solutions would cause the course to fail. Simple approaches with limited technology knowledge would make the participants feel more comfortable and motivate participants for usage.

There are various models for Web-based education implementations. These models can be defined as follows:

- **Individualised Instruction:** This model is a text based individual system with the support from a faculty, similar to the traditional distance education approach. Only, there are channels to facilitate the submissions of the assignments, grades and feedbacks on-line.
- **Class Model:** In this model, a number of students work together within a single faculty. Web-based approach is a medium for the participants to communicate with each other, for submissions and feedbacks. However there is little communication between the students.
- **Integrated Class Model:** This model includes student-to-student interactions. In addition to the lecture notes, submissions and feedbacks of the previous approaches, it involves research activities and audio and video conferencing.
- **Group Model:** small group collaboration is conducted similar to the Integrated Class Model. It requires one faculty per course.
- **Collaborative Group Model:** This model is the one that cooperates all of the previous approaches. Series of courses or a course with multiple faculties is offered in this model. It includes a consortium of educators with multiple resources (Jones and McCormack, 1996).

In the case study of this thesis, the Collaborative Group Model will be used, in order to encourage students for group works and to provide communication with more than one instructor. It is preferred because the course chosen for implementation, Modular Interior Systems, involves correlation between various subjects such as interior design, construction methods and materials, building performance, detailing, product

design and CAD. Therefore, communication with other students and instructors is provided.

3.3.3 TOOLS AND MATERIALS FOR DESIGNING A WEB-BASED COURSE

Design is the third step to prepare a Web-based course. Implementation of the Web-based classroom is related with the tools that will be used. The appropriate tools should be chosen related to the nature of the course. Many tools ranging from simple programs written by a person to large expensive software packages can be used.

There is a wide variety of tools to construct the communication between the participants such as e-mails, Newsgroups, FTP and chat. The Web-based classroom provides facilities that support a number of types of communication mechanisms, which have many advantages over traditional face-to face communication. For instance, the participants may have one-to-one communication to talk privately with other members using e-mails, interactive chats or video conferencing or Web-based presentations and announcements can take place by one-to many communications.

Also, a single message can be sent to all members of the class via e-mail broadcasting. In addition, the feedbacks such as evaluation forms in a Web-based classroom can be provided by many-to-one communication. The most beneficial way of communication is many-to-many communication over traditional means. Mailing lists, interactive chats, audio or video conferencing can be used for this purpose.

Course material is converted into HTML format for preparation of Web pages including lecture notes, images and necessary graphical materials, hyperlinks to the

related sites on the WWW, connection to mailing lists and supplementary documents such as assignments, homework or quizzes. These course pages may be in pure HTML format or may include sound files, image files and other graphics. Also, they may include Java and JavaScript formats or may be presented in VRML format.

3.3.4 DISTRIBUTION OF INFORMATION

After the preparation of the learning material, they are stored on one or more computers, which are the distribution points for information. These materials stored on the computer enable you to search, archive, index and convert the material easily and quickly.

A Web-based education system is made up of the server, client and the network. The information is held on and the communication is directed by the server while the client provides the interface to the Web-based course that the participants use to perform tasks and interact with virtual classroom (Jones and McCormack, 1996). In order to connect to the server, the network is used. The messages created by the users are sent to the server with a browser by using a hyperlink or typing text commands, over the network. When the server receives the request from the browser, it performs the operations and returns the information to the browser, in other words, to the client. Various connections between the client and the server software is possible such as, LAN for university campuses or business, home connections with a modem and phone line, Hybrid with CDROM for slow speed modem connections (Jones and McCormack, 1996).

A set of rules, called connection protocols that govern the communication is needed through the network connections. HyperText Transport Protocol (HTTP) for retrieving web pages, FTP for transferring the files, Simple Mail Transport Protocol (SMTP) for sending e-mails, Post Office Protocol (POP) for receiving e-mails and Ewigie-specific Protocol for interactive chat are common examples for protocols for different purposes.

The more careful design and appreciation of student problems, the more effective way of learning is provided to the students through these high level technical facilities. The most common problem in a Web-based course design on-line is how to present the learning materials. Most of the topics can be taught using Web-based communication since all forms of communication and information distribution are supported. For instance, it is possible for the students to see slides related to a course, watch a demonstration of a scientific experiment or experience a space they have designed.

Additionally, various other techniques may be used to produce attractive and intelligent systems such as multimedia and artificial intelligence (Catenazzi and Sommaruga, 1999). Multimedia technology combines video, sound, picture, animation and text.

Although it seems a beneficial system, constructing a Web-based course is a time consuming procedure that involves a wide range of multi-disciplinary staff such as subject experts, video producers, graphic designers and computer programmers (Brett and Nash, 1999). Therefore preparation of a multimedia system should be in systematic organization. Hyper-media applications can be constructed, which are composed of self-contained units of information that can be translated as a web of

related subjects, called Hyper-media nodes. The important point here is that the students should be guided because they need to understand the relations and structure of the hyper-document (Hall and Mendes, 1999).

Before using the techniques decided, they need to be evaluated in order to see whether they suit the student's needs so that they can be applied when a need arises. After the evaluation, the information is ready to distribute.

The distribution of information can be provided by four different ways:

- The simplest use of web is the software distribution by the replacement media like disks, CD-ROMs and prints through downloadable materials placed on web page. The existing computer-based material such as Word Processor files is placed in a Web server. In this type, there is the advantage of geographical and temporal independence with the Web as a distribution medium.
- A second way is to convert the existing computer-based information into a native Web format such as conversion of text documents into HTML; animations into animated Graphics Interchange Format (GIF); photographic images into JPEG (Joint Photographic Experts Group); or VR applications into VRML format through automatic conversion program. In this way, the information is saved in the form of Web document presented in a platform independent way.
- A third way, value-added conversions uses the all benefits of the previous approaches and adds the audio and animation demonstration with Web support for media.
- Another way is to create and design new material specifically for the Web. Although it is the most beneficial of all approaches, it is a time-consuming

process, since special characteristics of the Web that are unfamiliar for most of the users are applied (Jones and McCormack, 1996).

The Web-based course created by one of these methods should be attractive to draw the attention of the visitors of the course homepage. Ease of access should be provided to prevent the loss of visitor in the virtual environment.

3.4 FACTORS EFFECTING THE SUCCESS OF THE DESIGN OF A WEB-BASED COURSE

In the design of a Web-based course, how the information is presented is quite important. A well-defined structure with clear paths should be prepared for a successful course design. It is important to present the aim of the course, expectations from the students and organization of the course material in order to prevent chaos. Also, the course presented should be easily accessible and should provide opportunities for the students to access the instructor when they need. Providing interaction with the other students would also draw the students' attention.

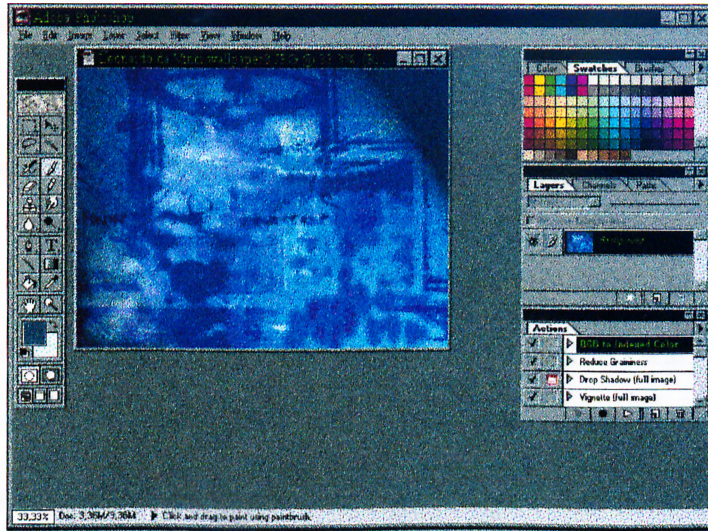


Figure 33: An example for a graphical tool, PhotoShop.

In addition to the ease of communication, the graphical presentation is also important to draw students' attention. Using the graphical tools such as PhotoShop [Figure 33], multimedia tools such as video display; programming tools such as Java and JavaScript; presentation tools such as PowerPoint; interactive tools such as hypertext and VRML enriches the design of the web pages of the course (Eğitim Seminerleri, 1998).

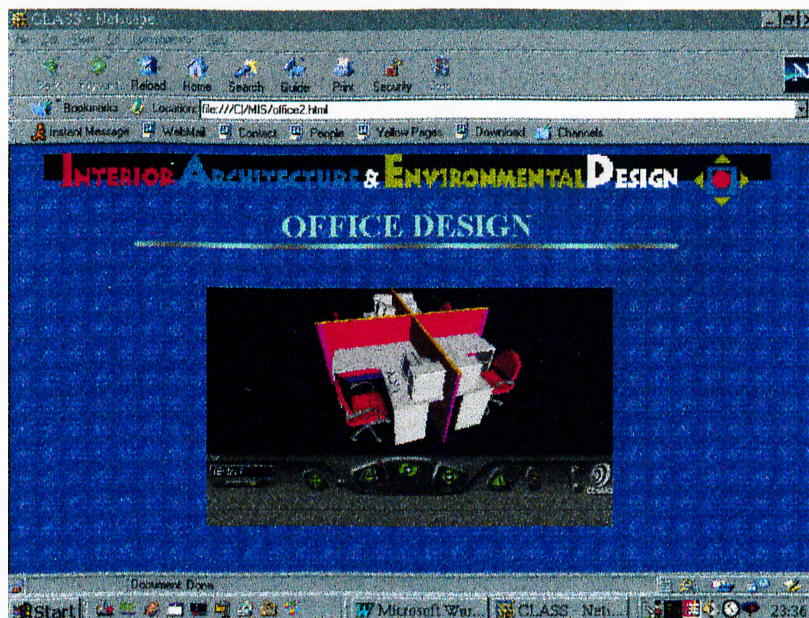


Figure 34: An HTML document example from the sample course design in which VRML is embedded.

However, choosing the appropriate tool for a specific data is an important factor in the design. For instance, presenting a 3D drawing within a VRML scene would be more attractive than a static 2D representation drawn in AutoCAD [Figure 34].

The visual organization of the course contents should be considered related to this concept for providing motivation to the student. A clear, simple and attractive design should be aimed at to draw students attention. Visual perception of human should be taken into consideration when organising a visual data. Borchers, et al. explain the human perception on screen, paper and in the physical world related to the laws of Gestalt psychology (1996). It is emphasised that the simplicity of the shapes used; the proximity, quality and unity in the elements used in designing groups of objects; continuity of objects and textual data; the visual experience in other words the familiarity of objects being used and moving elements are fundamental concepts for human perception (Borchers et al., 1996).

In this sense, in addition to the organization of the course, the graphical data such as colour, fonts or icons on the web page and the tools chosen for presentation should be well organised, in order to prepare a successful Web-based course. The expansion in the number of participants in the future should also be taken into consideration.

3.5 STUDIES IN WEB-BASED COURSE DESIGN

Recently, computers are not isolated in our desks any more. In the near future, it is expected that, the virtual design organizations will be supported by the virtual design studios that will enable the geographically distributed designers to work on the same project through the specific databases and resources, massaging, data exchange and

audio and video conferencing systems (Mitchell, 1998). Virtual working environments for scientists, physicians, and architects are being constructed through the development of interaction on the Internet. In this new concept, people are no longer just experiencing the simulations of the real world but also the computers are being integrated into their world. The ease of accessibility to global information with the pedagogical benefits of flexibility of asynchronous tools used on the Internet creates an increase in the use of Web-based education. This process reminds us the use of Internet for educational purposes. Computer mediated communication, especially in higher education can have a more flexible pattern of teaching using query and response systems such as audio and video conferencing, e-mail or chat; electronic learning centres including links to tutorials all around the world; International collaborations that shares different cultural values; global services such as WWW tools and Internet; and cooperative learning and development networks that brings the studies of universities and practitioners closer (Bryson et al., 1996).

There are applications of Web-based education in various universities for different levels from high school to PHD education programs all around the world. For instance, in an experiment conducted by CoNTACT Research Group in the School of Computing and Information Technology at the University of Wolverhampton, groups of undergraduate and graduate students were asked to locate and describe web sites with relevance to modules (Sloane, 1997). They were encouraged to learn how an Internet browser works and find the information sources individually. The students were also asked to justify the relevance of the web sites in order to see the discrimination between those students who put effort on the study. There were three different modules including, theoretical work, practical work and assessment. Principles of communication, human-computer interaction, data transmission,

protocols and standards were discussed for the theoretical study. Practical work was conducted through the university network and Internet, using browsers and e-mails. The assessment differed for the two groups. The undergraduate students were asked to prepare a case study and they were given a time-constraint exam while graduate students were asked to prepare an open-ended case study and a presentation. As a result, the web pages found by the students were ranging across networks and application topics. Many of the topics were off-topic. However the relevance of the topics were much better than it was expected (Sloane, 1997). It was seen that the freedom in the choice of the topics and easy accessibility of global information encouraged students to study more effectively.

The British Open University is conducting another Web-based course for 24 students from universities all around the world for the course Renewable Energy Technology (Hamalainen et al, 1995). A joint document is produced by exploring a virtual world to develop an energy policy for an imaginary country.

Another example is the Web-based education offered in the University of Sheffield in the Department of Information Studies (Bryson et al., 1996). Business, Information Management, Accounting and Finance courses are prepared for student groups of 24 in first and second year. In this system, a face-to-face meeting is held at first to introduce the course. Respectively, weekly theory input sessions and tutors are available for information and advice on-line. The Web-based course offered in New Jersey Institute of Technology for group communication; the system provided for the participants to speak with each other by typing texts in Nova University; and RIEDL, the system improved for exchange of video, voice and data information at

the University of Phoenix On-line can also be given as examples for technological developments in Web-based education (Hamalainen et al, 1995).

In the University of Desby, Web-based education is used for the exchange of visual work and ideas in the School of Art for the departments of Visual Communication, Applied Arts, and Textile and Fashion by using audio and video conferencing on line (Bryson et al., 1996). The system is conducted by full time lecturing staff, part time multimedia designer, design consultants and management team including the Dean, Assistant Deans, Heads of the departments and technical managers. In addition to the audio and video conference, papers are posted, criticisms and comments are made and technical support is provided for the student.

In the use of VE in design education as a new concept, 3D information is being shared as well as the 2D information between geographically distributed users. The most popular ones about design education are the projects and applications done at Michigan State University (MSU) and Massachusetts Institute of Technology (MIT). In MSU Virtual University, lectures have been prepared in many disciplines, such as mathematics, social sciences, psychology, telecommunication, Internet or CAD, without the time or place constraints of traditional university training programs [Figure 35]. The CAD courses offered on the Internet for design education provides an introduction to design issues and tasks by presenting the material through the Internet with on-site assistance in specific laboratories.

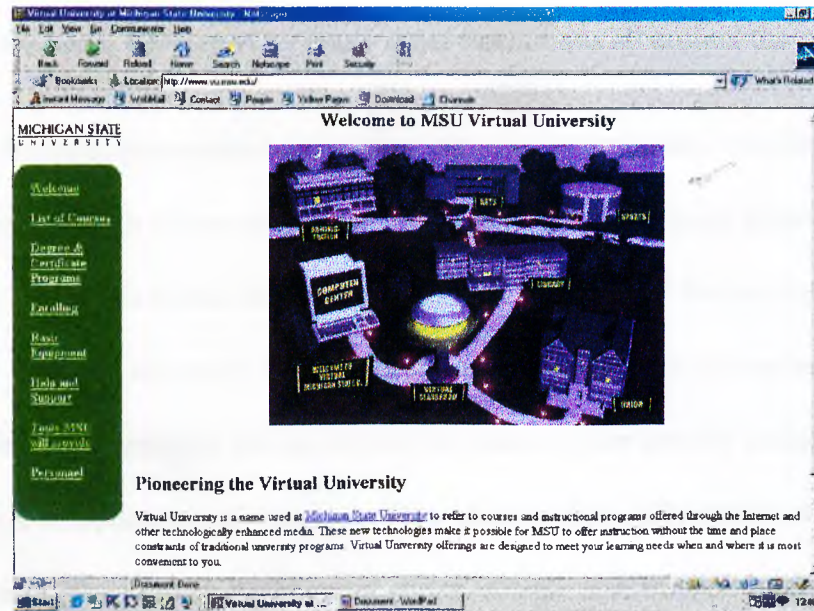


Figure 35: Web Page of MSU Virtual University (<http://www.vu.msu.edu>)

MIT, on the other hand, has developed a project called “Design Studio of the Future” in the Faculty of Architecture (Mitchell, 1998). Similar to MSU Virtual University, the project aims to delete the time and place constraints with synchronous distributed collaborative design on the Internet, WWW and other commercially available communication systems. The project aims to create virtual design studio with network facilities that provide geographically distributed participants in a design project with access to the organization databases and computational resources, efficient messaging and data exchange, and video conferencing (Bharwani et al., 1998). The communication between the geographically distributed students and instructors in these systems is provided with lecture notes, interactive homework or assignments, e-mails, on-line chat, virtual desk crits and web conferencing. The students may also have the opportunity to work with 3D CAD models and prototyping, visual reference databases and consultants on the net. Finally virtual juries are conducted on-line for the evaluation of the student’ s works.

Other applications of Web-based courses similar to the ones that are explained in this chapter are being developed by many other institutions all around the world.

Taking these sample systems and opportunities of Internet into consideration, interior architecture design course can also be prepared and offered as an extension course via Internet. In this thesis, the senior interior design course Modular Interior Systems given in Bilkent University is chosen as a sample Web-based course because of its comprehensive approach that points out the nature of the interior design education. It includes the application of the most of the courses previously taught in the interior design area. The drawing techniques, spatial design, construction methods, finishing materials, furniture and details are evaluated in addition to the concept of modularity. A sample web-based course design for this course is presented in Chapter 4, offering the opportunities of Internet. It includes theoretical, practical applications and communication mechanism with the instructor. VRML has been used as a tool to present the course material.

4 A SAMPLE COURSE EXTENSION DESIGN IN INTERIOR ARCHITECTURE EDUCATION FOR THE COURSE ‘MODULAR INTERIOR SYSTEMS’

Architecture, as a discipline between science and art, is stated to be a natural application area for VR including tectonics which is the principle of architectural construction, lighting and materiality (Kurmann et al., 1995). The study of interior architecture involves the relationship between people and environment including the relationship of interior and outdoor designs (Kness et al., 1980). In this sense, the senior interior architecture course “Modular Interior Systems is chosen for the application. Computers can help to make collaboration of designer and the client throughout the design process and create a change in how architectural design adjust to the technology (Mills, 1995). What is more, computer aided practices in architectural design can help the designer to see the failures and missing parts. However, designing with computers should be different than the traditional methods; it is important to make the computer work in our world rather than us working in computer' s world (Chalmers, 1994). Related to this idea, as a new development in computer technology, VRML has been chosen as a tool for implementation that is used for the exchange of 3D information on the global network, the Internet. In order

to choose the tools to prepare an architectural design course on the Internet, the nature of the course should be evaluated.

4.1 NATURE OF THE 'MODULAR INTERIOR SYSTEMS' COURSE

Interior design involves many decisions to be made about spatial design, construction systems, details, materials and furniture that will be used throughout the space. The correlations between these elements and their properties are taught in interior design courses. The courses of each year involve a correlation between the studied courses in addition to the previous year's courses' topics and requirements. The last year's lectures involve all of the requirements and the knowledge of the previous years. The students are prepared for the professional life by using all the knowledge they have gained, to make decisions and design a space.

Similar lectures are prepared under various course names in different universities to train students about these subjects. One of the lectures that is given to improve and combines the knowledge about interior design in the fourth year, at Bilkent University is Modular Interior Systems (See Appendix D]. We know that both the buildings and the interior of the buildings are designed by using functional and dimensional repetitive individual units in various dimensions. These units are called "modules". Modularity brings flexibility to the designer as a result of ease in design process, production, usage and mounting. Also it permits reconfiguration of the units. Because of these, modularity has a wide range of use in the design of the components of the space such as floor, wall, ceiling and furniture. Today, modular systems are

widely preferred both by the designer and consumer. So it is important to educate the new designer generation about modular systems.

Related to this idea, the course Modular Interior Systems is offered to the senior students. It is a course that involves the concept of modularity and the applications of the previously thought courses such as Technical Drawing, Architectural Design Graphics, Interior Design, Construction, Material and Detailing, in addition to modular design.

In this course content, the concept of modularity is discussed at the beginning. Then the students are asked to prepare presentations and information sheets about the finishing materials and construction systems used in interior design. Finishing materials and construction systems are modular elements that are commonly used in the design of an interior space. A design problem is given afterwards, to experience the use of these elements in spatial design, such as a space design of an office, kitchen or bathroom. The students prepare a project about this design problem, taking the drawing techniques, spatial design, construction systems, finishing materials, furniture and details into consideration. Working technical drawings in various scales, details drawings, 3D representation of the space (axonometric or perspective views) and material schedule are required for the final evaluation of the course, as if the space is to be constructed.

To sum up, since this course points out the nature of the interior design practice, it has been chosen as a sample extension course to make an application on the Internet. The course design and construction processes will be explained in the following sections. In order to offer such a course on the Internet, the instructors and the students attending the course should have a basic knowledge on CAD and Internet.

Especially, if the instructors will construct the course themselves, they have to know how to use AutoCAD, 3DStudioMAX and operations related with Internet, HTML and VRML works.

4.2 CASE STUDY: COURSE DESIGN FOR ‘MODULAR INTERIOR SYSTEMS’

The design of the sample extension course for Modular Interior Systems is similar to the traditional course offered in Bilkent University because it is designed as an extension to help the students and the instructors (See Appendix C). As an example for the use of VE in interior design education, the design proceeded in the following manner as explained in Chapter 3.

Step 1: Defining the scope

At first, the scope of the course has been defined. It has been decided that a study of concept of modularity and the elements of modularity, especially the market products, shall be contained in the course material. This theoretical knowledge is supported by applications including 2D and 3D projects and finally a final interior design project is decided to be given in order to let the student use the knowledge gained about modularity.

Step 2: Methodology

Since the course chosen is a course that reflects the nature of interior design, it includes support from other courses such as Technical Drawing, Interior Design, Construction and Materials, Detailing, CAD or Building Performance. For this reason, the Collaborative Group Model has been preferred to provide support for the students for other subjects.

A series of different space design projects can be included such as office, bathroom, kitchen or laboratory design. In this exercise, office design process has been included as an example. In addition to the instructor of the designed course, it is possible for the student to communicate with the different staff about key points related with these different subjects.

Also, students are encouraged for group works with the other students in the class. In this study the virtual crits is offered for student and the instructor however the application is not included.

Step 3: Tools

For this sample course design, various tools have been used for construction of the course. The textual data has been prepared in HTML format by Netscape Composer [Figure 36].

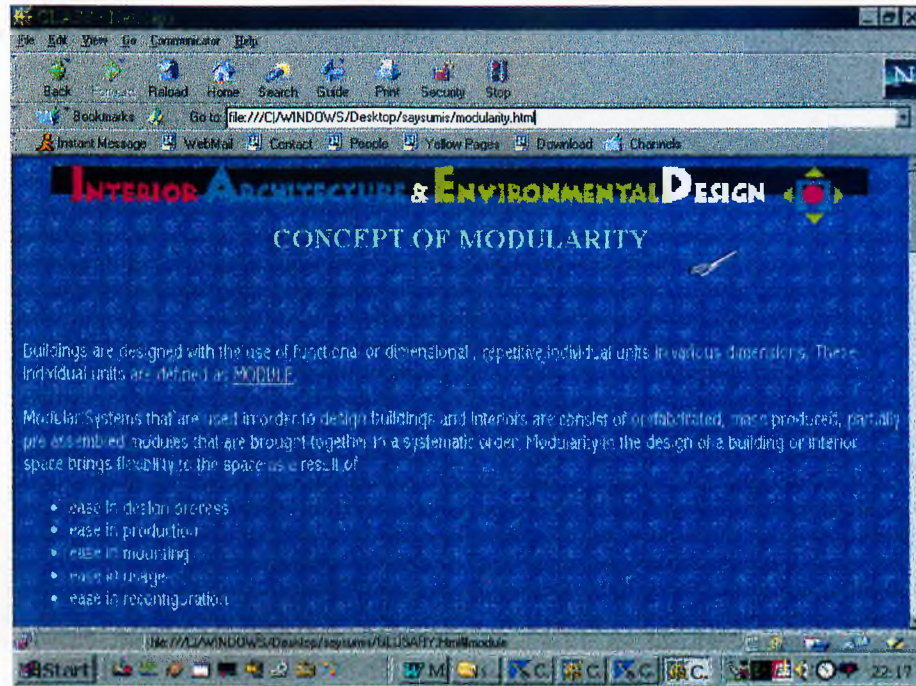


Figure 36: A view from the Theoretical Study Page, explaining concept of modularity.

A slide show of Microsoft PowerPoint has been preferred for displaying the lecture notes, in order to prepare simple and attractive notes [Figure 37].

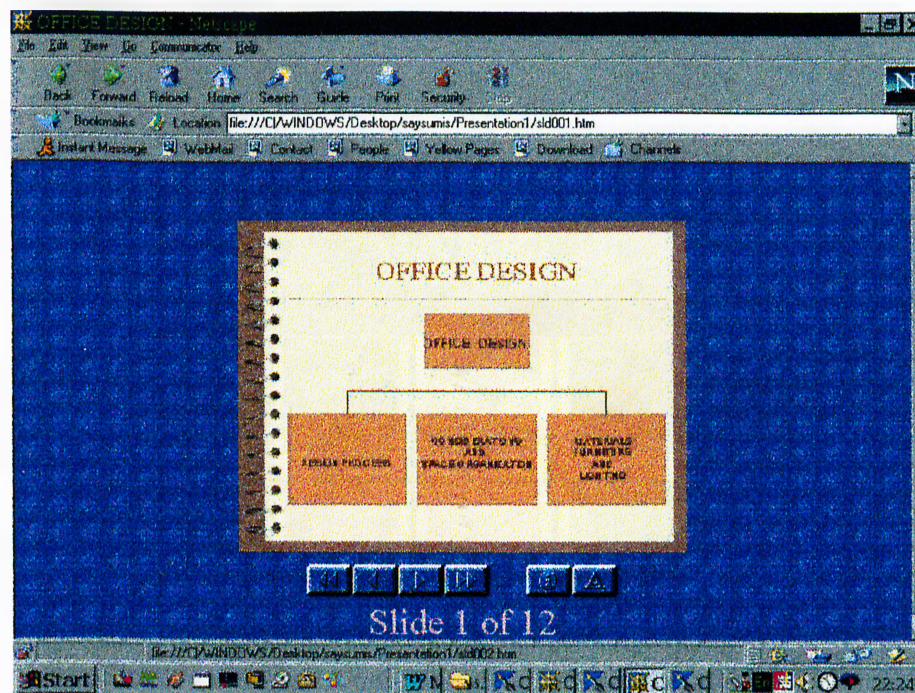


Figure 37: A view from the Theoretical Study, explaining the basic concepts in office design using slides.



Figure 38: A view from the previous projects about 2D Modular Design.

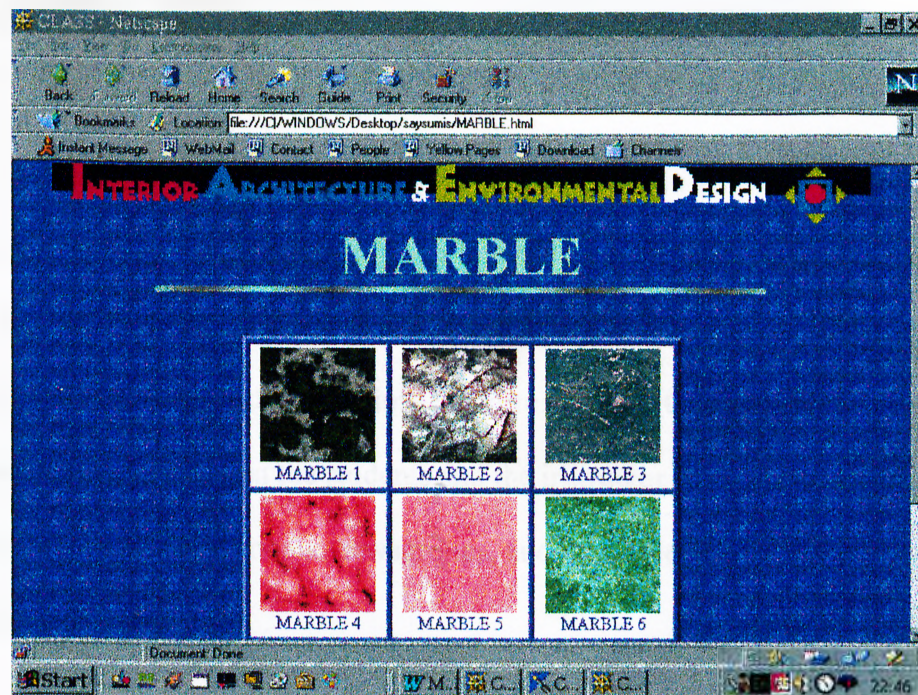


Figure 39: A view from the library of textures.

Static drawing data such as orthographic drawings and perspective views are prepared with 3DStudioMAX, AutoCAD and PhotoShop [Figures 38,39]. However most of the 3D drawings included in the course are presented in the VE [Figure 40].

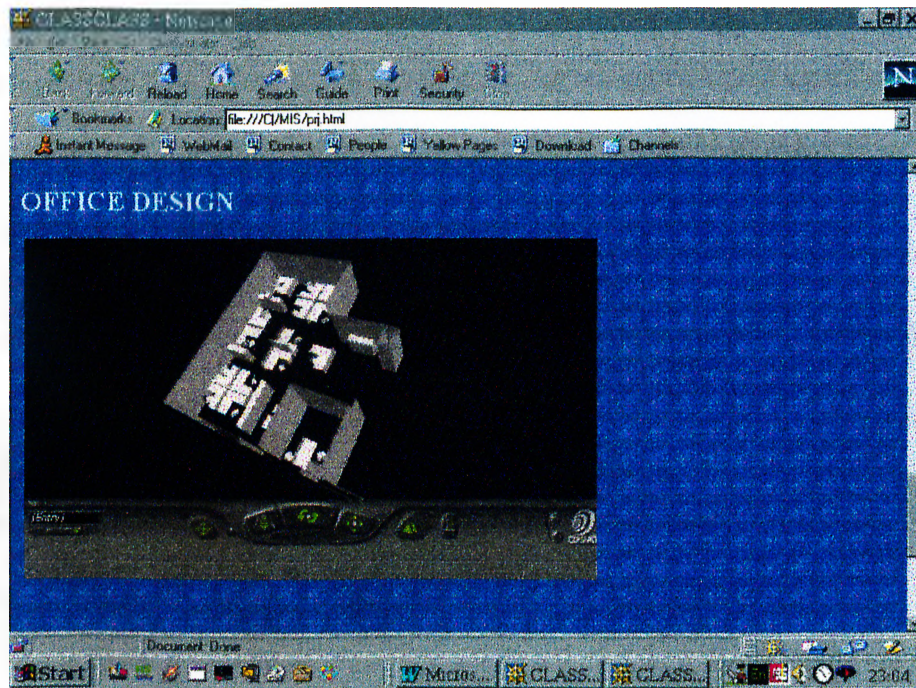


Figure 40: An example from previous student projects about office design.

After a study of widely used browsers, converters and authoring packages, Cosmo Player 2.1 has been chosen for the application and 3DStudioMAX Converter is used for converting the 3D sample drawings into the virtual world. Other tools are used for the communication between the students and the instructor or the other staff and group works are e-mail, chat rooms, newsgroups, audio and video conferencing and virtual meeting for crits.

Step 4: Materials

In order to present the course, the materials have been prepared using the tools that are chosen. During the construction the number of materials are increased to improve the web pages.

- Lecture notes have been written explaining the concept of modularity and office design. Previous student researches about the concept of modularity have been added [Figures 38, 40].
- Previous student projects are collected to be used as samples and crits about the projects are added.
- Drawings of modules that are used for modular design have been prepared with AutoCAD and 3D ones are converted to VRML format [Figure 41].

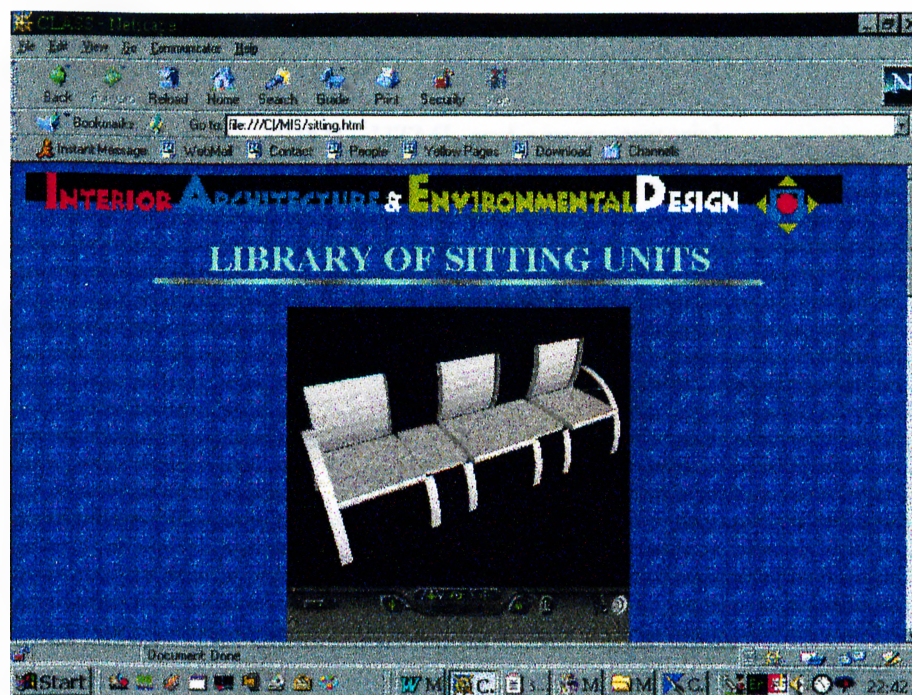


Figure 41: A view from the library of sitting units.

- Texture samples have been created in PhotoShop for the texture library [Figure 39].
- Photographs of furniture have been scanned or collected from Internet. 3D computer models of furniture have been found and converted into VRML format for the furniture library.
- Detail drawings have been scanned or drawn in AutoCAD for the detail library.
- Useful references such as links in the Internet, books or consultants are collected and organised.
- A glossary of terms has been prepared as a reference for the student.
- Icons, background images, 2D images and animated images have been found and prepared in order to construct the web pages.
- Information pages have been prepared for supporting and helping the students about technical concepts, VRML, HTML and course material.
- The communication page has been prepared for submissions, announcements and virtual crits [Figure 42].

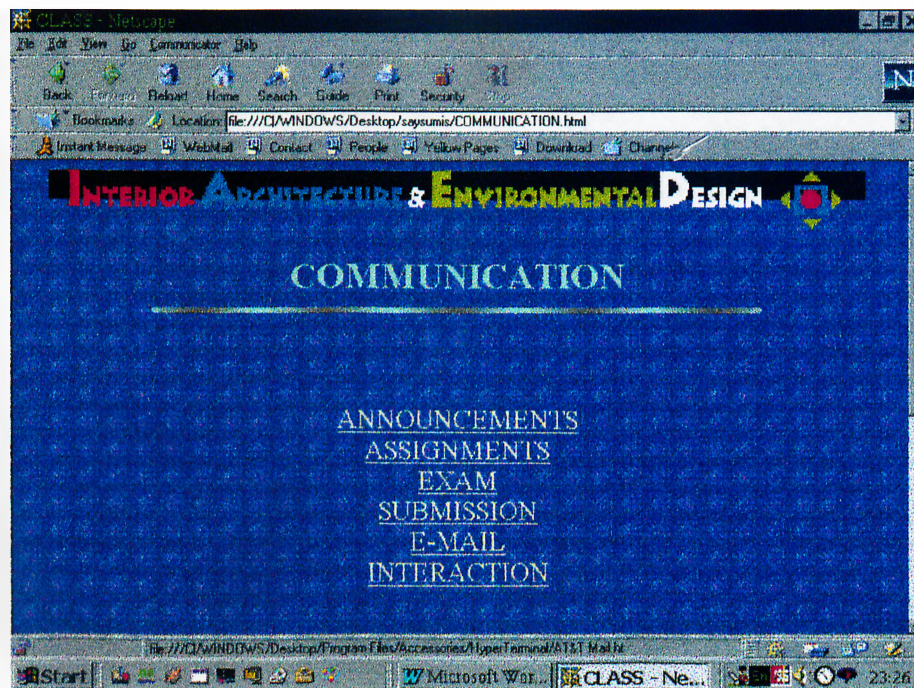


Figure 42: A view from the communication page.

The submission of exams, projects and quizzes is possible in two ways:

e-mail: The student can send the projects or exams to the e-mail address of the instructors.

FTP: The data can be sent to the site created by the instructor by using FTP.

Step 5: Construction

After the preparation of all of these materials, the home page of the course Modular Interior Systems [Figure 43] and the other sub-pages are constructed combining related pages via hyperlinks and presented at the address:

<http://www.bilkent.edu.tr/~saysu>.

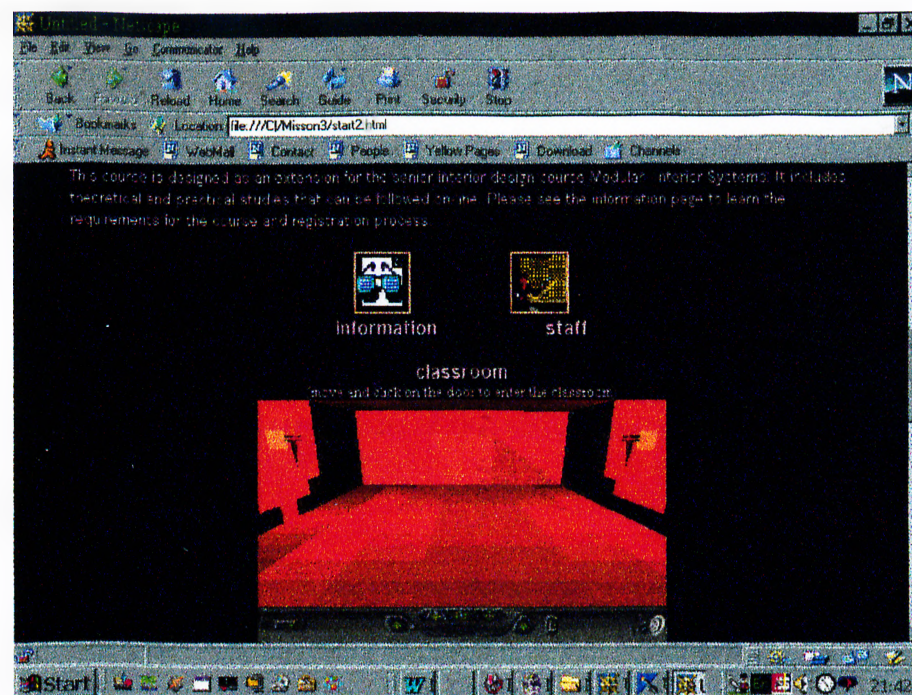
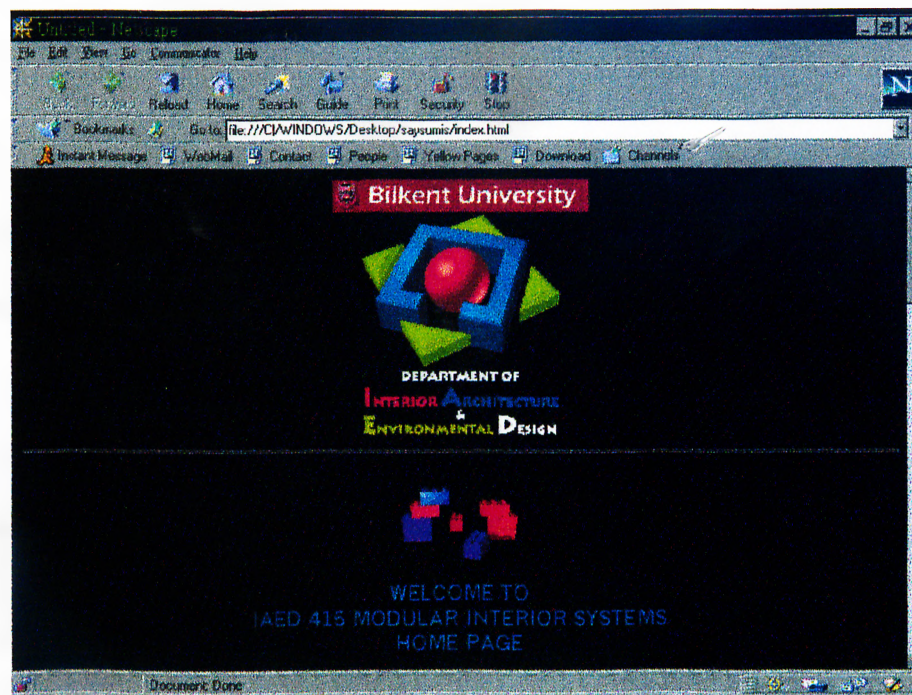


Figure 43: The home page of sample course design for Modular Interior Systems (<http://www.bilkent.edu.tr/~saysu>)

In order to add the sub pages of the course, an organization for the links and the contents of the web pages has been prepared [Figure 44].

The organization of the sample course design is composed of four basic parts. The first two rooms, Information and Staff, are accessible by anyone who wants to have information about the course and who wants to register to the course. In this part, rules and regulations of Web-based course are also included. Additionally, requirements about the course and technical requirements such as hardware and software requirements are also mentioned in this part.

The other two rooms, Classroom and Results, are accessible by passwords for those students who have registered for the course. A system for providing password to the participants should be constructed for such an application.

The organization of the rooms may be changed and improved as a result of an evaluation.

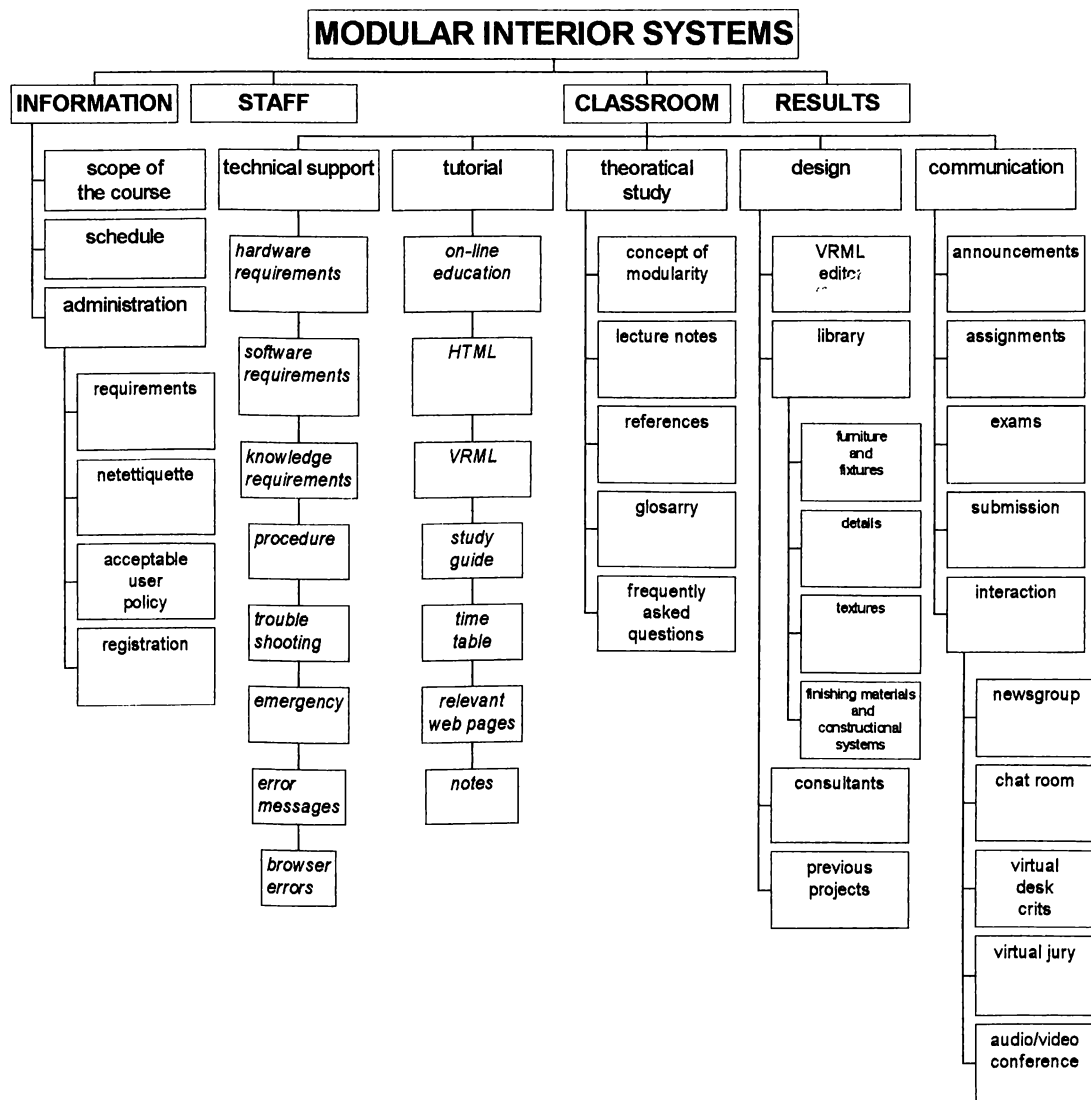


Figure 44: Organization of the sample Web-based course.

The classroom, which is the main part of this course, is composed of Technical Support to help students with error they may face; Tutorial for Web-based course, HTML and VRML; Theoretical Study for textual information; Design for 2D and 3D drawing support including libraries; and Communication to provide interaction with the other participants and the instructors.

In the results room, the evaluation results of the instructor takes place. The instructor can evaluate the textual material such as quizzes and exams by using checklists on

the computer. For instance, a Web-based course management tools may be used for multiple-choice or interactive exams, such as CyberProf, TopClass, Test Creator or Web Worksheet (Jones and McCormack, 1996). In order to evaluate drawings and guide students for their project, the instructor may send messages and advice via e-mail. Also, if the instructors have knowledge on AutoCAD, 3DStudioMAX and VRML, they can make changes on the student's project and send it back to the student using FTP. Chat programs and audio or video conferencing can also be used for discussions and crits. Additionally, a system similar to the MIT's Virtual Desk Crits in Virtual Design Studio of the Future, can be developed and constructed to enable discussions on projects between the geographically distributed participants. In this way, the crits can take place completely through the Internet. However if such a system is not constructed, the crits may take place partially in the school with face-to-face meetings and partially on the Web using e-mail, FTP, audio/video conferencing and chat programs.

Step 6: Evaluation of the Course Design

In the last step, before offering the course on the Internet, the course design should be evaluated in order to find the mistakes, missing or unnecessary parts related to the factors explained in the research. Otherwise the course would fail to serve the needs of the students.

The course chosen for implementation includes more than verbal information. Thus time is needed to offer the course in a term to a group of students to see advantages and disadvantages of a Web-based course for interior design education. In other words, students and the instructors should have a chance to experience the course in

a term. In this way, the failing or missing parts of the course may be changed or developed to improve the quality of the education. After such an application, the course design can be evaluated to see whether:

- the concept of modularity is well explained,
- the sample projects are appropriate,
- the assignments are appropriate to evaluate the success of students,
- the crit on the Internet can help students to develop their projects,
- final evaluations can be properly made, and
- there is a appropriate correlation with the other courses,

In addition to the design of the course information, the graphical design of Web-based course is another important factor, which would effect the success of the course as it is explained in Chapter 3. In this sample extension course design, a graphical organization related to the concept of modularity is used. For instance, two different background images are used in the homepages of topics.

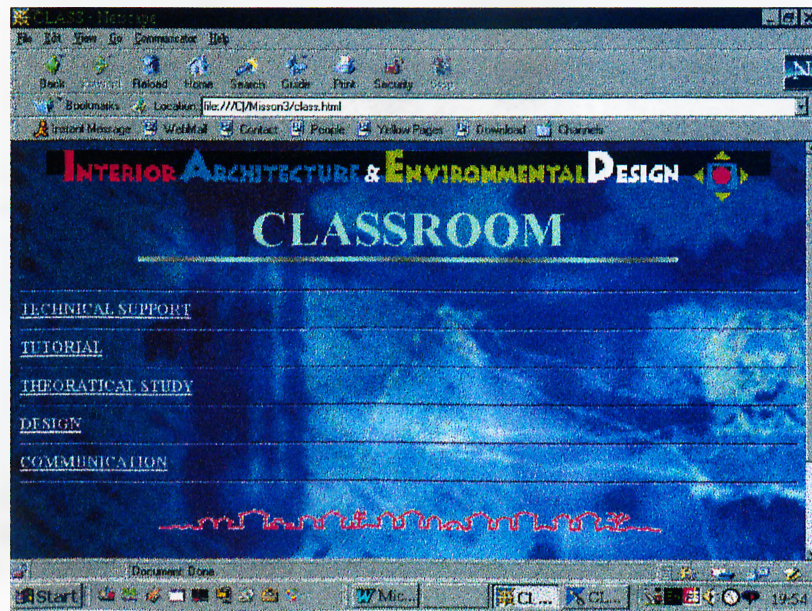


Figure 45: A view of the Classroom page.

In the four introduction rooms of the course (Information, Staff, Classroom and Records), an abstraction of the famous drawing of Leonardo Da Vinci that shows the relations of human body dimensions, is used; since the concept of modularity was studied related to the human body dimension in early times [Figure 45].



Figure 46: A view from the Technical Support Page in which technical requirements and troubleshooting is included.

In the following pages, a repetitive square module is used related to the concept of modularity [Figures 34, 36-42 and 46]. Blue has been preferred for both of the pages in order to provide a relation with the homepage of Department of Interior Architecture and Environmental Design of Bilkent University on the Web. All of the pages include the same header and footer to provide a unity. Simply, in the graphical design of this course, all of the pages are prepared as modules following each other.

The advantages of this sample Web-based extension course can be summarised as follows:

- The students do not have to work in fixed class hours.
- Instructors do not have to work in fixed office hours, they can have freedom in time arrangement.
- The course material is available as soon as it is on the Internet.

- The students and instructors are not restricted to work in school.
- It is possible for a disabled student to take such a course. For instance, disabled students have a chance to study the course material at home. Also, textual data and drawing used to present the course is useable by students with audile disabilities.
- The students can reach to the information they need whenever they want.
- The students can observe the previous projects and reach to crits about them.
- Communication with the many instructors, authorities and market is provided for students.
- Students are encouraged for group works and discussions.
- Students are encouraged for research on the global information network, Internet.
- It is easier for the students and instructors to see the failing or missing parts of the student projects.
- The students do not have to make many models or draw many perspective views to express their ideas on their project since VE provide “live” environments to experience different points of views of the project.
- It is easier to work on the project by using libraries offered in the course.
- It is possible to test the lighting design in the VRML environment.
- The self-oriented study provided by Web-based course give a chance to the students to have a more control over their own education.

Using these advantages, the students would also learn the advantages of use of computers in architectural design process for saving time and effort, which would also be useful in their professional life.

4 CONCLUSION

In this thesis, VE and Web-based education have been discussed related to the idea of using VE in interior design education. This has been supported by a sample course designed for the senior interior design course “Modular Interior Systems”. This course has been preferred for implementation purposes because it is a course that reflects the nature of interior design practice. Furthermore it combines the knowledge gained throughout the previous years of the Interior Architecture education. Thus it is possible to see how other courses such as Design Studio, Construction and Materials, Detailing Studio and Computer Aided Design can be offered via Internet.

The advantage of using computers in various disciplines is their capability to carry out long sequences of huge data and operations at a high computational speed. In this sense, the use of computers in architectural design can speed up carrying out calculations, documentation, specifications, drafting and presentation activities. It can help to cope with complexity in design process by holding, scanning and restructuring large amounts of information (Reynolds, 1987). With the developments of new computer technologies such as 3D modelling and VE, it is now possible for the designer to construct the projects before it is being built physically in order to check the design for failing or missing parts (Becker and Weizel, 1996). The ability to control a viewpoint of two-dimensional moving image and the ability for the

observer to access and manipulate the data, including representation choice increases the experimental understanding. In this way, the observer can also control the sequence of events that is being observed (Van Dam, 1993).

Although construction is quite expensive, designers could save time and money throughout the design process in architectural design practice if they use VE (MacLeod, 1992). However, it is possible to integrate the computers to design practice by integrating them into design education (Şenyapılı, 1993). In this way students can learn to use computers and technological developments in VE to handle the sophisticated procedures of design process.

In addition to use of VE in design process VE can also be used for world wide exchange of information. As an essence of education, exchange of information would have a wider application in VE through networks like Internet in the near future using various tools such as VRML to train people for various professions. The use of VE in architectural design education can be extended in the future studies to solve the problems related to Web-based education. In order to construct such a course and help to provide platforms related to the Web-based education, a collaborative study of various diciplines is needed such as, graphics designer, computer technicians, computer programmers and instructors of the courses.

In order to prepare this sample extension course employed on the Internet, the VRML world is experienced with various tools and libraries for the course content are constructed using VRML. The sample course extension design is just an example for such an application to give an idea of how an interior design course can be offered to students on the Internet. It includes tools that can be used to present the visual data, which is the most important point in the design education.

Before offering such a course on the Internet, an evaluation of the course should be made. However, as it is not possible to evaluate the design and tools of a traditional design course in statistical means without offering it to the students, it is not possible to make an evaluation of this sample Web-based course. An evaluation can be made using evaluation forms and face-to-face interviews with the participants, to see the advantages and disadvantages of the course after offering it throughout a semester and thus allowing the students and instructor to experience the course. After the evaluation, such a course design can be improved further to compensate deficiencies.

To sum up, the aim of this study has been to point out the use of VE in interior design education. It is apparent that that the Internet and VE within the Internet are encouraging people for working and doing research by enabling them a new point of view. In this way, both the students and the instructors can benefit from the advantages of global communication on a virtual environment. This study and the sample extension course design for interior design education is an example for this new point of view.

APPENDIX A

WEB-BASED EDUCATION EXAMPLES

- **DESIGN STUDIO OF THE FUTURE-at MIT**
<http://auto.mit.edu/dsof.nsf>
- **MSU VIRTUAL UNIVERSITY-Michigan State University**
<http://www.vu.msu.edu>
- **DISTANCE EDUCATION PROGRAM -Texas Tech University, Collage of Engineering,**
<http://www.texastech.edu>
- **VWSU- at Virtual Washington State University**
<http://www.eecs.wsu.edu/rada/vwsu/index.html>
- **CYBERPROF SYSTEM at the University of Illinois**
<http://cyberprof.uiuc.edu>
- **GEMBA- The Global Executive MBA Program at Duke University**
<http://www.duke.edu/~Clemen/gembadm.html>
- **CoNTACT RESEARCH GROUP- The School of Computing and Information Technology in University of Wolverhampton**
<http://www.wlc.ac.uk>
- **UNIVERSITY OF SHEFFIELD**
<http://www.shef.ac.uk>
- **UI-ONLINE- at University of Illinois**
<http://www.online.Uillinois.edu>
- **BRITISH OPEN UNIVERSITY**
<http://www.open.ac.uk/frames.html>
- **CASO INTERNET UNIVERSITY-Collage courses by computer**
<http://www.caso.com>
- **SUNY- Top Classes System, at State University of New York**
<http://www.id.ucsb.edu/detche/library/distance/topclass.html>
- **SCALE-University of Illinios at Urbana Champaign by Alfred P. Sloan Foundation**
<http://w3.scale.uiuc.edu/SCALE>

- **FTTC's Virtual Campus**
<http://www.faytech.cc.nc.us/infodesk/vcampus/vcampus.html>
- **VEE Virtual Education Environment – Athena University**
<http://www.athena.edu/campus/vee.html>

APPENDIX B

VRML TOOLS

- **VRML BROWSERS**
 - Cosmo Player by Silicon Graphics, Inc.
 - WorldView by Intervista Software
 - Virtus Voyager by Virtus Corporation
 - 3D Website Builder by Virtus Corporation
 - Community Place by Sony
 - OZ Virtual by OZ Interactive
 - Passport (Viewer) by 3D Blaxxun Interactive
 - Platinum WIRL by Platinum Technology
 - RealSpace Viewer by Live Picture
 - Terraform VRML Browser by Brilliance Labs.
- **VRML CONVERTERS**
 - 3D Studio VRML Converter by Autodesk
 - DXF VRML Converter
- **VRML AUTHORING PACKAGES**
 - 3D View by Actify
 - 3D Webmaster by Superscape
 - Cosmo World by Silicon Graphics, Inc.
 - Gweb by Virtual Presence
 - Liquid Reality by Dimension X
 - Pioneer by Caligari Corporation
 - VRCreator by Platinum Technology
 - Virtual Home Space Builder by ParaGraph International
 - SpaceCrafter J3D Tool Kit by InWorld VR

APPENDIX C

INTERIOR DESIGN COURSES OFFERED IN BILKENT UNIVERSITY

1ST YEAR COURSES

Basic Design 1 - 2
Technical Drawing and Lettering 1 - 2
Drawing 1 - 2
Introduction to Art and Culture 1 - 2

2ND YEAR COURSES

Interior Design Studio 1 - 2
Construction and Materials 1 - 2
Building Performance: Physical Factors
Computers and Geometry
Human Factors
Advanced Design Graphics
History of Built Environment 1 – 2

3RD YEAR COURSES

Interior Design Studio 3 – 4
Building Performance: Codes
Building Performance: Services
People and Environment
Computer Aided Design
Detailing Studio
Product Detailing

4TH YEAR COURSES

Interior Design Studio 5 - 6
Modular Interior Systems
Professional Practice
Interior Design Documentation

APPENDIX D

SYLLABUS OF “MODULAR INTERIOR SYSTEMS” OFFERED AT BILKENT UNIVERSITY in the 1998/1999 FALL TERM

WEEK 1: Introduction to the Course; Concept of Modularity, Modular Interior Systems.

WEEK 2: Modular Coordination Exercise in Geometric Modularity: Sketch Design.

WEEK 3: Explanation of Research Topics Exercise in Modular Unit: Sketch Design.

WEEK 4: Research Presentation.

WEEK 5: Explanation of Term Project.

WEEK 6: Crits.

WEEK 7: Crits.

WEEK 8: Preliminary Jury.

WEEK 9: Revisions, Details.

WEEK 10: Details, Materials, and Specifications.

WEEK 11: Final Crits and Revisions.

WEEK 12: Final Submission of Drawings.

WEEK 13: Final Submission of Specification and Material Schedule.

WEEK 14: Jury Evaluation

APPENDIX E

LIST OF ACRONYMS

ASCII	American Standard Code for Information Interchange
CAD	Computer Aided Design
CDF	CyberSpace Description Format
FTP	File Transfer Protocol
FAQ	Frequently Asked Questions
GIF	Graphics Interchange Format
HTML	Hyper Text Mark-up Language
JPEG	Joint Photographic Experts Group
MEME	Multi-tasking Extensible Messaging Environment
MPEG	Moving Picture Experts Group
OOGL	Object Oriented Graphics Language
PNG	Portable Network Graphics Specification
SGI	Silicon Graphics Inc.
SMTP	Standard Mail Transfer Protocol
VAG	Virtual Architecture Group
VE	Virtual Environment
VR	Virtual Reality
VRML	Virtual Reality Modelling Language
WWW	World Wide Web

LIST OF TERMS

ANIMATION: Any graphic method where rapid viewing (at least 16 frames per second) creates illusion of motion, of individual frames in a sequence.

ASYNCHRONOUS TEACHING: Asynchronous Learning is a terminology used for learning anywhere, anytime, meaning that the learning process of a particular subject is performed without fixed class hours at classrooms.

AUDIO CONFERENCING: A conference involving participants at remote locations facilitated with audio communication links.

AVATAR: An image or 3D figure that represents the user in the virtual environment.

BROWSER: An application that lets the user access World Wide Web servers in order to surf the Net or view local files.

CD-ROM (Compact Disk- Read-Only- Memory): A read-only computer medium that contains computer data.

CHAT: A system that allows two or more people to participate in synchronous, usually with text-based, communication on line.

CLIENT: Any computer using the services of a network.

CYBERSPACE: It is an infinite artificial information based space or world where people can navigate.

DATABASE: The entire set of graphics objects available on-line for rendering by a graphics system as applied by a user.

DOWNLOAD: Sending data from a host computer to an independent processing unit or peripheral device for local storage and subsequent quick access.

E-MAIL: A system used for sending and receiving text-based messages on line.

EVENT: An indication that something has happened.

FIELD: A data element contained in a node to describe the attributes of the nodes.

FREQUENTLY ASKED QUESTIONS: A list of questions that are usually asked.

HYPERLINK: An electronic link between one object to another.

HYPER TEXT MARK-UP LANGUAGE (HTML): A language used for exchange of information that includes 2D images and textual information, using hyperlinks to various sources on the Internet.

IMMERSION: The sense of being physically and psychologically in the virtual environment.

INLINE FILES: VRML files that are embedded into another VRML file.

INTERACTIVITY: An electronic simulation in which perspective images are generated in real time from a stored database corresponding to the position and orientation of the head of a user, who observes the images on a head-mounted display, and in which three dimensional sound cues are provided as well as a means for interaction with objects in the database.

INTERNET: A world wide digital data network.

INTERPOLATOR: A node that uses a mathematical formula to fill in the values between two specified values, transiting smoothly from one to another.

LEVEL OF DETAIL (LOD): Alternate representations for an object in the scene with varying degrees of complexity, as a function of distance or projected size, to minimise the rendering time.

MAPPING: To project a two dimensional pattern or image on to flat or curved surfaces.

MARK-UP: A term used for the sequence of characters or other symbols that you insert at certain places in a text or word processing file to indicate how the file should look when it is printed or displayed or to describe the documents' s local structure.

MODELLING: Activities related to the construction of a graphics database, as distinct from the rendering process for producing images from a database.

MODEM: Modulator-Demodulator. An electronic device that is used for communicating computer data over telephone lines by controlling the frequency , pulse width, or other characteristics of signals.

MOTION SICKNESS: A condition that occurs when people are exposed to real or apparent motion stimuli to which they are unfamiliar and unadapted.

NODE: The basic unit of VRML that contains data for the scene in the form of the fields.

OPEN GL: A graphics language, administrated by Architecture Review Board, that defines syntax and structure for 3D graphics that informs much of VRML.

OPEN INVENTOR: A 3D graphics description technology created by Silicon Graphics, Inc., that shaped much of VRML and its capabilities as a language.

PIXEL: The smallest element on a raster display for which the colour or the intensity may be independently set.

PROTOCOL: Specification of the hardware and software interface to network.

PROTOTYPE: A template for new node type, which defines the fields and events that form the interface to the node.

ROUTE: A connection between two events.

SCRIPT: A program, written in a language, such as VRMLScript, JavaScript or Perl, which is contained in the Script Node.

SENSOR: A node that monitors a particular type of event, processes the input, and generates output events.

SERVER: A computer shared over a network, usually to provide common storage or compute resources.

SYNCHRONOUS TEACHING: A method of teaching on-line in which all communicating participants interact with each other at the same time.

VIDEO CONFERENCING: A conference involving participants at remote locations, using video images of the participants communicated as well as voice.

VIRTUAL ENVIRONMENT: Multi-dimensional interactive computer generated environments that enable people to act in and upon a space with varying degrees of time.

VIRTUAL REALITY: An electronic simulation or display that suggest the sense of involvement or interaction with the data in real time.

WIRING INSTRUCTIONS: VRML world building instructions that describes how to wire nodes together to create a dynamic world.

WORLD WIDE WEB: A group of world wide information resources connected over the worldwide network, Internet.

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